MILITARY AVIATION

CLÉMENT ADER

EDITED AND TRANSLATED BY

LEE KENNETT

Military Aviation

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Air University Press
Maxwell Air Force Base, Alabama

July 2003

Air University Library Cataloging Data

Ader, Clément, 1841–1925.
Military aviation / by Clément Ader ; edited and translated by Lee Kennett.
p. ; cm.
Includes bibliographical references.
Originally published Paris : Berger-Levrault, 1909.
ISBN 1-58566-118-X
1. Aeronautics, Military. 2. Aeronautics, Military—France. I. Title. II. Kennett, Lee B.

358.4—dc21

Air University Press
131 West Shumacher Avenue
Maxwell AFB AL 36112-6615
http://aupress.maxwell.af.mil

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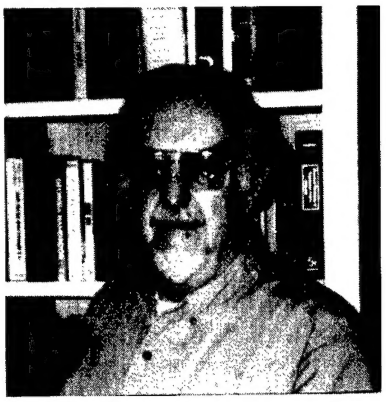


Lee Kennett received his doctorate in history from the University of Virginia and spent most of his teaching career at the University of Georgia, retiring there as Research Professor of History in 1993. In the course of his career he held three Fulbright professorships, served as Lindbergh Professor at the National Air and Space Museum, and taught at the Sorbonne (Paris IV) and at the École Pratique des Hautes Études (4th Section), where he holds the title of directeur d'études associé. In 1994 he was decorated by the French government for "services to French culture."

Dr. Kennett's research interest spans the last three centuries and includes both American and European military institutions. His publications on the history of military aviation include *A History of Strategic Bombing* (New York: Charles Scribner's Sons, 1982) and *The First Air War, 1914–1918* (New York: Free Press, 1991), as well as articles in American and European publications. He edited and contributed to *French Military Aviation: A Bibliographical Guide,* written in collaboration with Général de Brigade Aérienne Charles Christienne, Patrick Facon, and Patrice Buffotot (New York and London: Garland Publishing, Inc., 1989). His work under contract with the US Air Force includes the opening chapter in *Case Studies in the Development of Air Support,* edited by Benjamin Franklin Cooling (Washington, D.C.: Government Printing Office, 1990) and the concluding chapter of *Case Studies in Strategic Bombardment,* edited by R. Cargill Hall (Washington, D.C.: US Air Force History and Museums Program, 1998).

Bibliographical Note

After its first appearance in 1909, *L'Aviation militaire* enjoyed considerable popularity; in the five years between its release and the outbreak of the First World War it went through 10 editions, each of which contained new material as heavier-than-air flight progressed from dream to reality and Ader found more to say. In addition he authored three other books: the first, *La première étappe de l'aviation militaire (The First Stage of Military Aviation)*, published in 1907, recounted in some 70 pages his work on his succession of aircraft designs. His *Avionnerie militaire. Pointage aérien*, published in 1912, appeared during the Balkan Wars, the first conflict in which aircraft were used. Fittingly, the book dealt with *avionnerie*, a term that never caught on, which Ader coined for the technical aspects of military aircraft. This book also considered construction and maintenance of military aircraft. The treatment of *pointage aérien* or bomb aiming contains Ader's ideas on the bombsight. Finally, *Les verités sur l'utilisation de l'aviation militaire avant et pendant la guerre* (1919), contains several plans Ader devised for the use of airpower during the First World War, plans which the French high command rather consistently ignored.

Ader left behind a considerable mass of manuscript material, of which the most interesting part is held by the Musée de l'Air et de l'Espace at Le Bourget, just outside of Paris; the museum's holdings include some 3,000 manuscript pages in Ader's hand, often containing the inventor's sketches. Scribbled in pencil and undated, they were essentially Ader's notes to himself and would be a considerable challenge to a researcher consulting them. Also in the museum is Ader's restored Avion No. 3.

Not surprisingly, most of the works written about Ader are in French; in keeping with his celebrity in his own country, many of the books and articles are more distinguished by their popular appeal than by their solid grounding in research on the man and his work. In a class by itself is the memoir of

Georges de Manthé, Ader's son-in-law: *Clément Ader, sa vie, son oeuvre* (Paris: Privat, 1936).

Fortunately there are three lengthy studies of the man and his accomplishments by eminent specialists. The first is by Charles Gibbs Smith, a distinguished British historian of early flight: *Clément Ader, His Claims and His Place in History* (London: Her Majesty's Stationery Office, 1968). The second is by the dean of French aviation historians, Charles Dollfus, whose appreciation of Ader fills an entire issue of the French aviation journal *Icare*, no. 68, spring 1974. Most recently Ader's story has been told again in *Clément Ader, inventeur d'avions* (Paris: Bibliothèque Historique Privat, 1990), by Gen Pierre Lissarrague of the Armée de l'Air. General Lissarrague wrote with an unrivalled hands-on knowledge of Ader's work; a former director of the Musée de l'Air et L'Espace, he more recently directed the restoration of Ader's Avion No. 3.

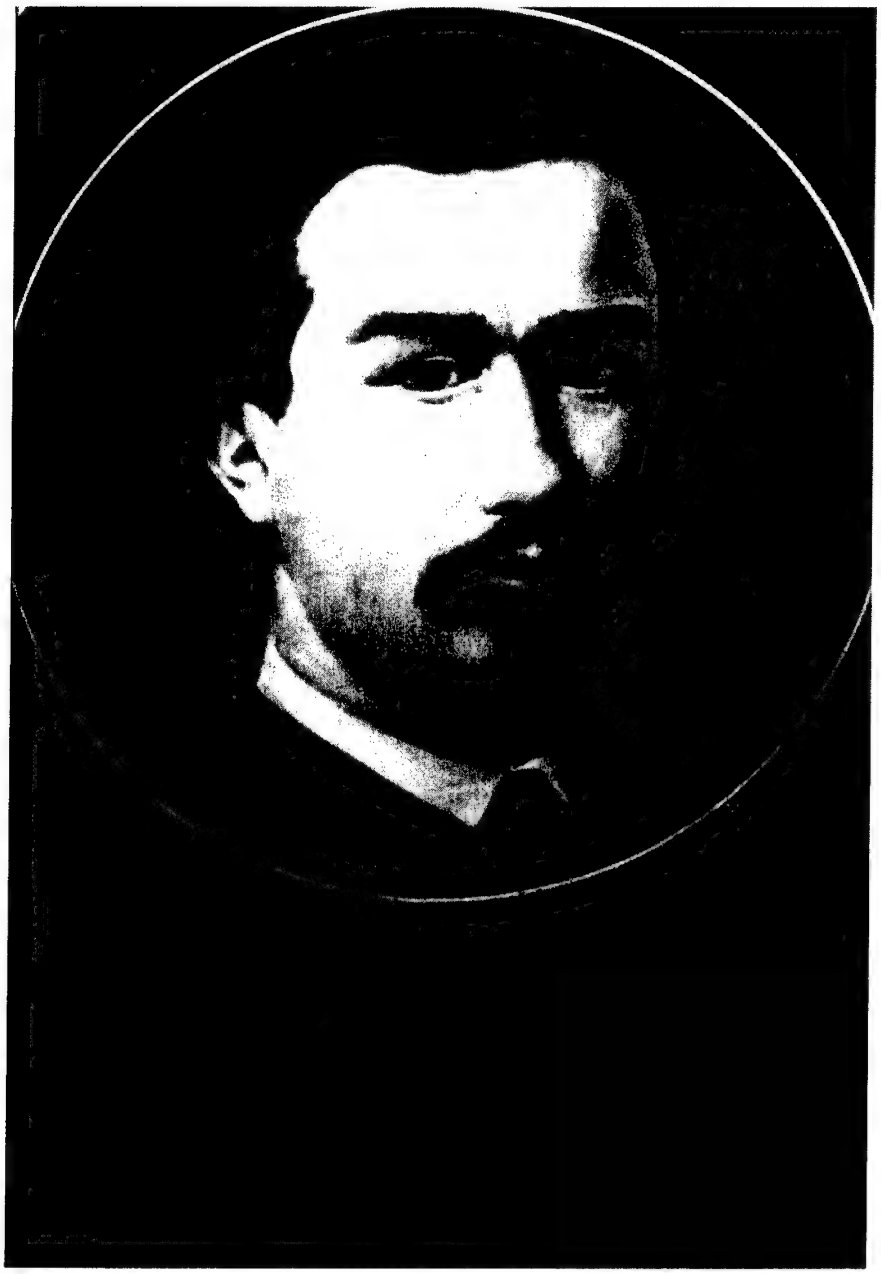
Foreword

When the names of pioneers of human flight are evoked, that of Clément Ader does not spring immediately to mind. The reasons are various: he was reticent, even secretive, about his work; what he wrote and what was written about him were rarely translated into English; then like his contemporary and fellow countryman Louis Mouillard, he believed nature held the key to human flight: a flying machine should take as its model a flying creature. If pursued too far, effort in this direction generally led to failure, and ultimately to ridicule for those who persisted in it. Even today it is hard to resist a smile when reading a description of Ader's "glider" of the 1870s, with its birdlike silhouette and its wings covered with thousands of goose feathers.

But Ader also followed another path, one where he was virtually alone in the last decade of the nineteenth century: even before the first warplane took to the air, he composed a remarkable treatise on military aircraft and their use, and on that broader concept we have come to call airpower. Like his aircraft designs, his *L'Aviation militaire* may provoke smiles from time to time, but it also stirs admiration for the remarkable gift of prescience its author often displayed.

The book appeared in successive editions, growing larger and more technical as its author incorporated various developments in aviation. But the first edition remains the most remarkable and the most evocative. That slim volume, offered here in English translation, contains ideas formed for the most part in the last decade of the nineteenth century, arranged in final form by the author in 1907, and published in 1909 by the Paris publisher Berger-Levrault. Since there is no biography of Ader in English, a brief outline of his life is offered here by way of introduction. The text of Ader's work is reproduced in its entirety, including various notes he added; the editor and translator has appended explanatory notes and a brief bibliographical notice.

Lee Kennett



Service Historique de l'Armee de l'Air

Clément Ader

About the Author

Clément Ader, 1841–1925

Clément Ader was born on 2 April 1841 in the small town of Muret, located in southeastern France, not far from Toulouse. It is worth noting that he was an only child; in his early years he was accustomed to playing alone, and in maturity he essentially worked alone. He confessed that as a small child he was already fascinated with all flying things and spent much time studying them. Every winged insect, bat, or sparrow that came into his hands received the most careful scrutiny. He coaxed some of the insects into flying with their wings enlarged by means of pieces of paper glued on—resulting in the first of many disappointments Ader would know in this line of research. And the same disappointment came with his earliest attempts to fly, those of a small boy, arms outstretched in a "bird suit" of his own contrivance, running downhill into a strong breeze. These attempts were made alone and at night, in a preoccupation with privacy that would also find expression in Ader's later years.

The milieu into which Ader was born is of some importance. His father was a cabinetmaker of good reputation, a man who was at home with tools and made his living working with his hands. Ader's paternal grandfather, who lived nearby, owned and operated a mill and spent much of his time keeping it in good repair. Thus from early childhood, the boy was familiar with the world of the craftsman; consummate craftsmanship would be a hallmark of his own work as a builder of aircraft.

Born into a family of very modest means in the stratified society of nineteenth-century France, Ader might well have ended his formal education at the primary level in the communal school of Muret, then entered into an apprenticeship, most likely with his father. But he excelled in his studies, taking several prizes, including one in French and another in mathematics; his teacher was so impressed with his intelligence that he urged Ader's father to let him continue his schooling. That could not be done in Muret; he would need to go to Toulouse, and since he had exhausted the opportunities of free education, there would be tuition to pay; moreover young Clément would have to be a boarding student. François Ader found the money to send his 12-year-old son off to Toulouse,

where he enrolled in a succession of programs until 1861. In each school he excelled in the same subjects: French, mathematics, and drawing and drafting. He later confessed that in those years he was torn between two possible careers—one as an inventor, the other as an artist. He added that in either case he would have made nature the source of his inspiration.

At that time the government-run institutions of higher learning in France all had conservative curricula; they did little to prepare young men for roles in the Industrial Revolution, which was even then beginning to transform France and all of Europe. But, in 1857 a private school in Toulouse called the Institution Assiot created a new division called the "Ecole Industrielle" for that very purpose. Ader enrolled, completed the program, and in 1862 accepted a position as a supervisor of work on the Bayonne-Toulouse rail line, whose construction had just started; thus began his long and fruitful career as designer and builder. While his various jobs and exact whereabouts through the 1860s are not all known, his career as inventor had begun. In 1866 he took out his first patent on a device consisting of a pair of jacks to aid in the laying of track in correct alignment (there is no evidence that the idea ever found practical use). Shortly his interest turned to bicycles, then called velocipedes and something of a late-nineteenth-century fad. Here he had some commercial success: he perfected the velocipede's design, replacing the heavy cast-iron frame with a lighter one of sheet metal, and to the crude iron rimmed wheels he added rubber tires.

Then in 1870 came *L'Année Terrible,* the "Terrible Year." The government of Emperor Napoléon III was drawn into war with Prussia and other German states; the French were ill prepared and badly beaten in the early battles, the emperor himself being taken prisoner at Sedan. A new provisional government of republican form replaced him and tried to carry on the war, while the Prussians and their allies proceeded to lay siege to Paris. The provisional government made peace with the Prussians in January 1871; but the radical leaders of Paris, the Communards, refused to accept the peace. In a final, tragic struggle, the French government then had to conquer its own capital in particularly savage fighting, while the Prussian Army of occupation looked on. France came out of the war militarily humiliated, diplomatically isolated,

politically divided, stripped of her province of Alsace and of most of Lorraine and finally, saddled with a heavy war indemnity.

A whole generation of Frenchmen was traumatized, and at the same time determined to return their country to the status of a great power; and more than a few Frenchmen of that era—Ader among them—also dreamed of settling accounts with the new Germany that had taken shape around a Prussian nucleus. Though Ader, then entering his thirties, had not been in the fighting, the national calamity would play a major role in determining his life's work.

The war had brought him back into close contact with that major fascination of his childhood, flight. Working for the government, he experimented with the use of large kites to take aerial observers aloft. Then with the return of peace he found time to conduct other flying experiments. In 1873, while at Castelnaudary, also in southeastern France, he conducted some remarkable experiments with a glider—the same one he had covered with goose feathers. Also remarkable was the fact that he went aloft in it—though without flying in the ordinary sense of the word.

In southeastern France there is an east wind characteristic of the region called the *vent d'autun*. It comes across from Spain at a speed of perhaps 15 or 20 miles per hour and blows for days. It is not a particularly welcome wind: farmers who need rain know that it will bring none; physicians in that part of France have claimed for decades that the wind depresses their patients. But for Ader and his glider experiments the *vent d'autun* was a most helpful friend.

To test the flying qualities of his glider under "scientific" conditions, he would ordinarily need a wind tunnel, but there were none in those days (Ader's fellow countryman Gustave Eiffel would build one of the first of these at the beginning of the twentieth century). So Ader installed his glider in a place where the *vent d'autun* would have free play and tethered the craft, facing into the wind, in such fashion that it could have limited movement up and down, but none in any other direction. He would then crouch inside this sizable artificial bird—it had a wingspan of nearly 30 feet—and when the *vent d'autun* was strong enough, glider and passenger would become airborne. The glider had the elements of a stabilizer in its tail surfaces, and Ader seems to have

used them to control his ascent and descent. But Ader's most recent biographer, General Lissarrague, has pointed out that Ader conducted far more valuable experiments with the glider: Attaching its tether to a dynamometer, he was able to measure the amount of traction needed to make the glider airborne, and hence obtain some idea of the power plant necessary to do this.

By this time Ader had made contact with others interested in flight, notably with a well-known professional photographer and amateur balloonist known simply as Nadar. Ader took his glider to Paris and put it on display in Nadar's studio, where it attracted the attention of the public. Unfortunately in France the chief figures in the movement to conquer the airways were devotees of the lighter-than-air solution, where France had a tradition of leadership (the first successful balloon flight had been the work of two Frenchmen in 1783); the Société Française de Navigation Aérienne was dominated by the partisans of the "aerostat," as the balloon was then called. Among its members, Ader's work found at best a tepid reception.

Ader, in the meantime, was staying in Paris in hopes of promoting an endless-track train system—each car had something similar to caterpillar treads. He had a miniature, goat-drawn version of his train built, offering free rides to anyone interested, but the idea did not catch on. Still another scientific innovation attracted him—the harnessing of electricity. He began working in telephony; as he progressed he registered patent after patent, and these would soon make his fortune.

In the United States Alexander Graham Bell was following the same path, creating his telephone company in 1877. When his representatives came to France to introduce the system there, they encountered Ader and his patents, and the result was a merger that proved profitable to all involved.

Ader now had the wherewithal to pursue researches in any direction he chose, and not surprisingly he returned to aeronautics; about that time Louis Mouillard had brought out a book on the ornithological approach to flight, spurring Ader's own interest. Mouillard had made a trip to Algeria to observe the flight of vultures, and in 1882 Ader made the same trip, which he relates in detail in *Military Aviation.* He also describes the trip he made to German-held Alsace to study the

flight of storks, which led to his being picked up by the German authorities on suspicion of espionage.

Returning to Paris, Ader set to work seriously to create his first *avion,* the name he had devised for any heavier-than-air craft, and which passed into the French language to become the equivalent of *airplane.* He had married in 1877, and now, in easy circumstances financially, he purchased a spacious house and lot in the city, adding to it a large, well-equipped workshop and in addition his own private aviary, in which he kept vultures and other birds and some imported bats for close study as his researches in flight progressed. He spent lavishly, employing a half-dozen or so skilled artisans in various specialties.

In the spring of 1890, after seven years of work, Ader completed his first flying machine, which he called the *Eole.* It was the first of three aircraft he would undertake, all of which shared the same basic characteristics. At the outset there were extensive tests of materials, various types of wood, textiles, metals, adhesives, and glues. The development of the *Eole*'s power plant took several years. Internal combustion engines were then in their infancy, crude and inefficient (a 100-horsepower model built under French government auspices in the 1890s weighed one-half ton). Ader opted for steam, with alcohol as the fuel for firing the boiler. The engine he built was pronounced by all who later examined it as a marvel of lightness.

Ader referred to the design of the craft as "bat-type." This was the first of three such craft Ader would undertake. The fuselage was essentially an oblong box with the power plant mounted forward. The pilot had no direct view ahead. The *Eole* had a porthole on each side.

The *Eole*'s wings, its most obvious and most striking feature, were closely modeled on the wings of bats. Anatomically they were perfect copies, or as nearly so as Ader could make them; moreover he labelled the various wing members forearm, elbow, thumb, or finger, and gave them the same articulations as in the bat's wing. When the *Eole* was at rest, its wings folded up against its body.

Ader could carry imitation only so far. He was obliged to strengthen each of the *Eole*'s wings with a supplementary "bone," a connecting rod. Nor would the craft fly as bats did, by the movement of its wings. Traction was supplied by a propeller attached to the craft's "beak." Without tail appendages

that could be manipulated—the *Eole* had a fixed rudder and no stabilizer—the craft would be ungovernable. In Ader's defense it should be said that he did not consider it a finished product, but more of a moving test bed.

In some ways Ader went to elaborate lengths to duplicate nature. For the four blades of the propeller, he chose the shape of a feather, and not just the shape. The blades also had to have the feather's construction. Thus each had to have a rachis or stem, to which the individual barbs were attached, then the barbs had to be joined, one to the next, to create the feather's bladelike form or "web." After much experimentation, bamboo and a special type of paper proved the best materials for this purpose; assembling each blade by gluing all of its elements must have been immensely time consuming.

Ader had neither collaborator nor understudy; he alone directed the work, imparting to it a direction that was distinctive and sometimes peculiar. He was not a scientist as we understand the term. He was inclined to the practical rather than the theoretical approach to a problem. Endless mathematical calculation was not his way of seeking answers; he preferred to conduct tests. Certain notions he held as articles of faith. For example he believed that there was a special type of curve, essentially a segment of a spiral, that nature had decreed for the wings of all flying things; this curve, the *courbe universelle de sustentation,* was to be found in the cross section of the wing and also in that of the propeller blade. He was persistently blind to the need for rapid and effective controls when in flight. At first he supplied almost no controls, but later he experimented with a far-too-complex system of pedals, cords, levers, and nuts to be turned.

Ader swore his workers to secrecy about their work, and from personal dedication to him they kept his secrets. His workshop rarely saw visitors; he would write of his work in correspondence with some other researchers with whom he was close, but then he would adjure them: "Don't talk about me or what I'm doing to anyone, please. I beg you, act as if I didn't exist." When the *Eole* was finally nearing completion, its creator registered another patent; this one, dated 19 April 1890, was for "a winged machine for aerial navigation, called *avion.*"

Soon it was time to conduct tests; Ader went to considerable pains to find an out-of-the-way place where this could be done without attracting public attention. He got permission to use the secluded country estate of the wealthy Pereire family at Armainvilliers. There in September and October 1890, Ader ran the *Eole* down a stretch of park, trying to coax it into the air. He and his assistants began lightening the plane by removing things not needed for brief runs—for example, the engine's condenser. Then on 9 October 1890, as the engine approached its peak of power, Ader suddenly felt a decrease in the plane's vibration. His assistants ran to check the wheel tracks and found that for a distance of about 50 yards the tracks had disappeared altogether. The *Eole* had left the ground briefly and barely, but it had become airborne. There is sufficient distinction between being momentarily airborne and flying. In French it is the difference between *voler,* to fly, and *voleter,* to hop about. Ader's partisans often claim for him the "first takeoff" of a heavier-than-air craft, rather than the first flight.

Any other inventor might then have called a press conference, but not Ader—though later he did put the *Eole* on display. He continued his tests, stopping in October after the aircraft was damaged. He had decided that he needed more space than that available at Armainvilliers. He obtained an audience with the French premier, Charles Salss de Freycinet, who was an engineer by training and quite willing to help him find a government installation where he could continue his work. Since Freycinet also held the portfolio of minister of war, he simply gave instructions to the army's chief engineer, General Mensier, who provided space for Ader at Satory, a sizable artillery installation not far from Paris. Ader carried out tests there in the late summer and early fall of 1891. Historians disagree on just how well the *Eole* performed at Satory—the records are too scanty to say with complete surety.

But there is no doubt that the *Eole* and its potential stirred considerable interest in military circles. General Mensier was enthusiastic. Premier Freycinet was also intrigued by Ader's work and especially its potential for national defense; he examined the *Eole* personally in October, and soon contract talks were under way between Ader and representatives of the War Ministry. Ader said he had spent 200,000 francs developing

the *Eole* and would need 300,000 to create an aircraft meeting the War Ministry's criteria. After some haggling the government agreed; the contract was signed on 3 February 1892. From the government's point of view it was very generous, and one is inclined to agree. If Ader succeeded in building an airplane that fulfilled all the government's requirements, he would receive bonuses of over 1,000,000 francs—and these were gold francs, a sizable fortune one century ago.

Considerable secrecy surrounded the project. Freycinet and his cabinet arranged to provide the money from funds already at the disposal of the president of the Republic; thus the funding was not subject to legislative scrutiny. Ader was to take out no foreign patents and no further French ones concerning aeronautics until he had fulfilled his contract. He and his workers were to carry out the project under *le secret absolu.* This was Ader's preferred way of working anyway, so the security provisions gave him no difficulty.

But the performance requirements for the aircraft he was to build would give him immense difficulties; they were in fact impossible of attainment at the time and would be for two more decades. The Ministry of War wanted an airplane that could fly at several hundred meters altitude, remain aloft at least six hours, attain a speed of 54 kilometers per hour, and carry one or two men. That the War Ministry was already thinking of a bomber seems clear; it wanted a machine that could transport 75 kilos of cargo, including explosive substances instead of the second man, and it wanted sufficient precision in flying to pass exactly over a specified point.

Ader set to work, but things did not go smoothly. As with all his projects, the work was meticulous, but slow and painstaking: in places the wooden members were joined by wrapping them in silk soaked in glue, with as many as 140 layers required; one of the glues used in assembly had to be cooked in a double boiler for more than a month. Then Ader decided to scrap his plan to build Avion No. 2, a larger and more powerful version of the *Eole.* He was concerned that the torque effect of a rapidly rotating propeller driven by a more powerful engine would disturb the plane's equilibrium and tend to throw it off course. The solution was to build a bimotor craft, Avion No. 3, with propellers turning in opposite directions and thus nullifying the torque effect.

But this meant abandoning some of the work already done—the design of the engine for Avion No. 2, for example—and retracing one's steps in other ways. Running out of money and time, Ader had to ask for a new contract and a fresh infusion of government funds. After much negotiation it was signed in July 1894, bringing Ader another 250,000 francs. The new contract contained language expressing the government's expectation that Ader would have Avion No. 3 ready for trials in the summer of 1895, though the builder was not strictly obliged to meet the deadline.

The government's seemingly inexhaustible patience and its willingness to put up more money are surprising. It may have preferred to continue rather than abandon the project after such a heavy initial investment and face a resulting scandal; then too, if the project were abandoned, Ader might look elsewhere for money, and in consequence place a potentially viable aerial weapon in the hands of some other power. The 1890s were, after all, a decade of alliance building, escalating armaments, and increasing tension throughout Europe.

It was not until July 1897 that Ader could send word to the War Ministry that Avion No. 3 was completed. The machine was duly moved to Satory, where trials began that fall. Having found the runway at Armainvilliers too short, and having no idea what distance Avion No. 3 would need to run before it became airborne, Ader had a runway created that may be unique in aviation history—it was perfectly round.

He had installed a steerable tail wheel on Avion No. 3, with controls that enabled him to direct the plane's movement on the ground from his position in the fuselage. The runway was 1,500 feet in diameter and about 120 feet wide. On 12 October 1897, he tested the plane on the ground, familiarizing himself with the controls; he apparently had no difficulty steering the craft around the runway. Two days later, with several eyewitnesses present, including two generals sent by the Ministry of War, Ader climbed into Avion No. 3 for what he probably believed would be his first sustained flight. His machine went down the circular runway for some distance, gathering speed, then it departed from it, veering out in a different direction at very low altitude if above ground at all. The aircraft was seen to tilt sideways as if

banking, then seemed to spin around in a quarter turn and come to a sudden stop. Bystanders who came running up found Ader unhurt, but his Avion had wrecked its undercarriage and shattered both of its propellers. Just what had happened or didn't happen has been the subject of a disagreement among aviation historians for a century. The two generals had the impression that the aircraft did not leave the ground. Aviation historian Charles Gibbs Smith, who dedicated an entire book to Ader's various efforts to fly, also says that Avion No. 3 never left the ground that day. Gen Pierre Lissarrague of the French Air Force, Ader's most recent biographer, contends that the plane flew 300 meters. Ader was at first reticent about the supposed flight; in later years he insisted it occurred.

This event was the culminating point in Ader's attempts to fly. He set to work repairing the Avion but sought more money from the government, which was disinclined to give it. Then too, it was a bad time for calm deliberations on relatively esoteric matters, for the Dreyfus Affair was monopolizing everyone's attention, and both the government and the army were under attack. The contract was voided by the government in 1898.

Though considerably embittered, Ader never lost interest in aviation. He spoke of Avion No. 4, which never got off the drawing board, but he needed to recoup his finances with work in other directions. He designed, built, and sold internal combustion engines; he developed and successfully marketed an automobile which carried his name; for a time he worked on a *hydroglisseur,* or hovercraft. Then in 1902 he gave Avion No. 3 to the Conservatoire des Arts et Métiers; it has recently been restored and is now in the Musée de l'Air et de l'Espace at Le Bourget. In 1905 he divested himself of most of his business interests, left Paris, and went back to Muret. He died there in 1925, full in years and honors.

In the field of aircraft design and development, Ader had no disciples; in his dedication to birdlike machines he was the last of his breed. Many of his notions about such things as aerodynamics passed away long before he did. He continued to write in his retirement years, a good bit of the material being polemical, defending his achievements and sometimes criticizing others. But he also published writings that dated from the period when

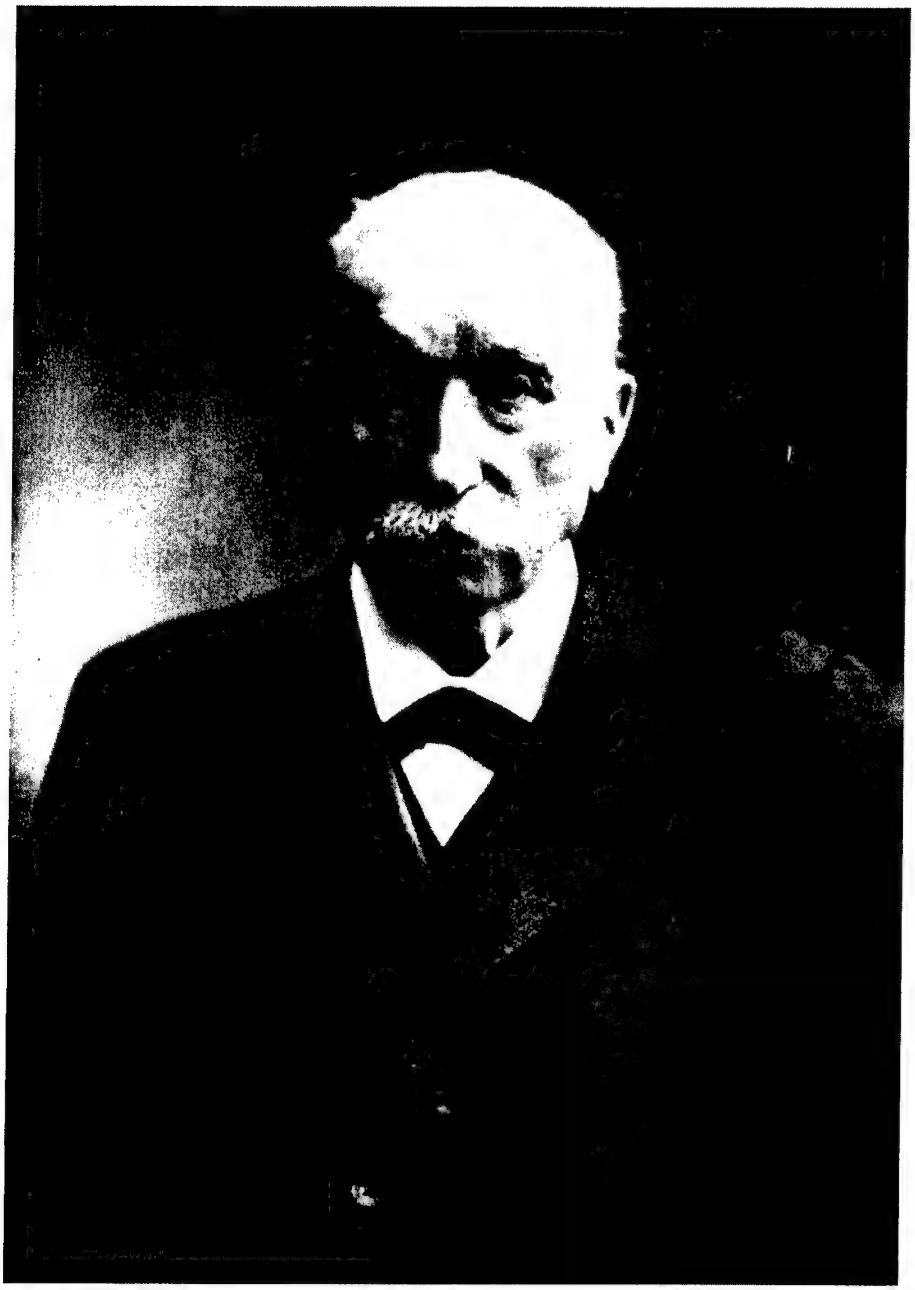
he was deeply engrossed in aeronautical matters. Some of these earlier products of his pen retain a certain charm and also a certain value; preeminent among them is *Military Aviation*, which attests to a remarkable intellect and a certain gift of prophecy.

Ader explained that he wrote from notes taken on various subjects in the 1890s, and in truth *Military Aviation* reads like something cobbled together from often disparate elements. In its pages the fanciful and the imaginary alternate with the soundly reasoned and the astonishingly prophetic, the whole having been assembled by something of a free spirit and served up with a Gallic flourish.

Ader described a vast expanse of "air lanes" that would carry the world's airborne commerce almost effortlessly, and that existed only in his imagination; he also imagined the *plancher de décollage*, a metallic gridwork that could be laid down over ground otherwise unsuitable for takeoffs and landings, and a half century later his idea became reality. There is the exotic program of study of Ader's flight school, with its field trip to Algeria for vulture watching; then there is the remarkably accurate description of the aircraft carrier, which would not come into existence for two more decades.

In this potpourri there are several basic ingredients. One is Ader's profound and unquestioning patriotism, and his conviction that he has found the way to help restore the grandeur of France. It was not taciturnity alone that kept Ader from talking or writing about his work; there was also his desire to confer on his country and no other the gift of dominance in the air.

Ader was a fervid believer in airpower even before there was such a thing. He advocated the independence of the air force and its equality with the army and navy; yet to his mind it was superior to its sister services. To him airpower was the supreme power: whoever controlled the skies would control the world. He took up issues that would agitate aviation circles for decades. Should one strive for simplicity and economy by building one type of aircraft suitable for several missions and uses? Ader said no, and airmen ever since have generally sided with him. But there are many other facets to this remarkable work, as the reader will discover.



Service Historique de l'Armee de l'Air

Clément Ader

L'Aviation Militaire

(Military Aviation)

by

Clément Ader

Eole

Introduction

War is humanity's greatest calamity; on this everyone agrees. But will we ever be able to put an end to it? Only from Europe might we hope for an answer to this question, and up until now we have had no hint of a positive response. Let us then at least try to reduce the evils of war. What we should strive to do is reduce the number of war's victims, and if along with that we could serve our country and provide for its defense, this would be the act of a good citizen and a good patriot. Military aviation has always seemed to me the necessary instrument for producing this doubly beneficial result; at least it has always been at the core of my thinking.

Before I took up this question of the national defense, I said to myself, since science belongs to no country, aviation might become the property of many. But being a simple inventor and a man who loves his country, I could think of nothing better than to clothe my work in secrecy, and this I did. In my brochure *The First Stage of Military Aviation in France,* I related the story that follows. I refer my reader to those sad pages, but for those who have not read them I will relate the essential facts.

The first airplane was the *Eole.* Begun in 1882, it was tested on a straight runway 200 meters long and located on the grounds of Armainvilliers, which belongs to the Pereire family. In one of these tests, on 9 October 1890, the *Eole* made a flight of 50 meters at a modest height, then suffered heavy damage which made it impossible to continue.

The next year, 1891, on a straight 800-meter runway at Satory, the *Eole* flew again, this time for a distance of 100 meters. Then it swerved from the track and crashed into the equipment used to level the field. On this test, as on the preceding one, I was flying the *Eole* myself.

M. de Freycinet, who was then premier and minister of war, wanted to see the *Eole.* On 17 October 1891, he came to see it in the pavilion of the city of Paris, where it had been placed. He was accompanied by General Mensier, head of the Fourth Direction (Engineers). M. de Freycinet decided to have the tests continued under the auspices of the Ministry of War and

in the interests of national defense. This was the first step in developing military aviation.

I was delighted, and I worked out a general plan embracing the foundation of a school of aviation and aircraft design, the establishment of a facility for aircraft manufacture, aerial tactics and strategy, and the creation of an air force.

A large laboratory was specially built and equipped; it was placed under military jurisdiction and became in fact the first school of aircraft design. During this time I was preparing in advance notes for courses in a future school of military aviation. The notes are the basis of this book.

From the laboratory came Avion No. 3, with which we carried out experiments on a circular field prepared at the camp at Satory by Lieutenant Binet. The minister of war had named a commission with General Mensier at its head. On 12 October 1897, I took the avion around the track, covering 1,500 meters in little hopping flights. On 14 October 1897, the weather was bad, with the wind blowing in gusts.

General Mensier and General Grillon were there. Taking advantage of a period of calm, I sought to take off. The avion had just left the ground when a very strong wind started up again and blew me off the track. Instinctively I shut off the motor. An unfortunate landing on very rough ground followed, after a flight of 300 meters; the machine was shattered.

The avion, this instrument of war, was thereupon abandoned by the minister of war. Then it was taken up by Arts et Métiers, and I owe my gratitude to its administration for having saved the machine from total ruin.[1]

Plans for Military Aviation

Since I first began working on military aviation, much time has elapsed. It has been 10 years since my most recent activities, some 15 to 25 years since the bulk of my work, and my first efforts go back much further than that. These efforts were all carried on behind closed doors, first on my own decision, and then later on the wishes of the government. Consequently, when they appear now, they are like ghosts returning. Of what do they consist, I am often asked. I will try to answer, but all

my productions were burned (except for Avion No. 3); to bring them back from their ashes I would need to live my life again, and I am now in the evening of that life. So I will limit myself to what my memory can supply, and what I can find in the scattered notes that escaped destruction.

My ideas concerning the aerial army I wanted to organize have not changed in 20 years. My basic ideas are two: first, flawless construction, for I thought that aviation should represent the ultimate in the field of mechanics; second, scrupulous observation of the laws of nature, so that they can be applied to airplanes. I became persuaded, and indeed certain, that those who will fail in the future will be those who did not understand these great principles.

This is still my belief today, though I have no quarrel with anyone who believes otherwise, particularly if that person should be among our potential enemies. When military aviation makes its appearance in Europe, we will inevitably see extravagantly nonsensical things. We will witness incredible air battles. They might be compared to fights between cocks and eagles; for though these two birds are perfectly suited to their functions, I have always been wary of them as representing two extremes.

Such conceptions are very far from the idea of an all-purpose airplane, and they have led me to the very simple deduction that each type of airplane should be made for the function it is to fulfill. This idea might seem at first glance perfectly natural, but its realization was not easy because the function was not known. The reader should not be surprised to learn that in that era now long past I first undertook to seek out those functions. This was what inspired my earliest work, which later became the basis for the courses to be taught at the future school of military aviation. The school of aircraft design in which these principles would find expression and application in material terms would come later; this was only natural.

At that time the war of 1870 was only a few years behind us, and I had not begun the *Eole*. Our generation had suffered cruelly; the humiliation that had been inflicted on France affected all patriotic Frenchmen of that era, and it especially affected me. My goal was in a sense imposed on me, and that

goal could be summed up this way: to organize an aerial army that would avenge an affront offered to our country.

Having fully reflected upon the overall and specific features of all my ideas on the organization and operation of an air force, I decided on three categories of aircraft: (1) the bombers, (2) the scouts, and (3) the airplanes of the line.[2] Each of these three categories could be subdivided into several categories, as experimentation and the requirements of their functions might dictate. Nor was this all. I had to concern myself with their subsequent use in war, their maneuvers, their formations, their armament, their combat methods, and their evolutions on the fields for takeoff and landing—this in order to deduce their function, this unknown element that could not be found by studying plans for airplanes themselves.

This line of thought took me even further and led me to consider the duties which would fall to the leaders of this air force, and hence I had to take up strategic considerations and tactical means; for if the air weapon were to be a serious one, we would need leaders versed in using it successfully in aerial combat. I would not have been satisfied with simulating military actions, such as children do with lead soldiers. I wanted to train genuine strategists and able tacticians, and at the school of military aviation courses would have been designed accordingly. Let me explain further: it seemed to me that this aviation school could only be a very scholarly establishment, for the simple reason that the air war itself would take on an essentially scientific character, in no way comparable with land armies and navies.

Thus we would ultimately have had an air force. What joy we would have felt in knowing that France had the first one in Europe, and our joy would have increased when I saw a way of keeping our lead through the organization of a school of military aviation whose foundations I was already working on!

Aeronautical Construction

Along with the plans for organization mentioned above, I had research and testing under way for aircraft construction. The research guided the tests, and both advanced together.

The element of function, this indispensable unknown—now began to take on form, and the plans for airplanes became more practical and more capable of realization.

First of all I had to find out how an airplane of very general type would behave—that is to say, if it would fly. I built *Eole,* the first airplane. The first studies for it were made in 1882, and the construction was completed in 1889. The machine was very well adapted for flight; it was of bat-type, folding up when not in use, so that it took up little space. During tests in 1890 it flew only 50 meters; the next year it flew just 100 meters, then piloting errors and damage to the machine brought the tests to an end. But the *Eole* had flown two times, carrying a man and flying under its own power: that was all I wanted to know.

Without wasting time with new experiments using the *Eole,* which would have taken one or two years, I drew up plans for the three distinct types of airplanes I mentioned earlier: bombers, scouts, and airplanes of the line. In 1892 I began planning projects and working to create the first category, the bomber, which I divided into four types:

First type—Avion No. 3, of the bat-type, whose wings folded when not in use, had motive force provided by a steam engine that generated one horsepower for every three kilograms of weight. It could have been made quite large, because the power generated was not as limited as with gasoline engines. This machine is at Arts et Métiers, so it does not need to be described further. It flew at the camp of Satory in 1897, under the auspices of the War Department.

Second type—Avion No. 4, with framework and covering similar to the preceding, but with a gasoline motor; the cylinders were to have been maintained at a temperature of 100° (centigrade) by a two-stage cooling system with water surrounding the cylinders and liquid or vaporized alcohol in a small condenser or radiator like that of Avion No. 3. This type would have retained the usual dimensions. The means of landing would have been much improved. It would have kept its two propellers, but they would have been aligned side by side; they would have folded as in the *Eole.* The minister of war did not permit the construction of this Avion No. 4.

Third type—Avion No. 5 would have benefited from the improvements made on its predecessors; it too would have had twin engines using gasoline motors. It would have been distinguished from its predecessors by its bat-type wings which would have been extendable and retractable in flight, in order to increase or diminish their surface, and also in order to alter the spiral curve of sustentation.[3] It would have flown very well aloft in bad weather and in the air lanes.[4] It would have been of use as a high-altitude bomber.

Fourth type—Avion No. 6 was the last of the bombing category; its wings would have been of vulture form, movable in flight, with alterations and also with changes in the spiral curve of sustentation similar to the bat wings described earlier. A small, extendable, and movable tail would help in steering when the wings remained in a fixed position. This Avion No. 6 was not to have been built until the completion of the types in the other two categories for which the urgency seemed greater.

The second category, the scouts, would have required a greater amount of study and work, but this did not discourage me, and I would have carried them through to completion just the same. Given the difficulties, I would at first have made only one type—the eagle type, preferably—then later would have taken up a second type—that of frigate bird. These two would have been Avions No. 7 and No. 8. They would have been created for their chief function: high-speed flight.

These scouts would have had the following characteristics: a small, very tapered body; a long neck carrying a single propeller; and the rear tapering to a point that would carry a directional tail. The propeller would be adjustable in pitch and in the amount of surface, with the blades capable of being lengthened or shortened, and capable of being folded back when they were not being used, as when flying in air lanes or descending. There would have been a very light and very powerful motor, with cylinders of tempered steel and with a dorsal radiator for secondary cooling, the cylinders being cooled by water, the water by alcohol, and the alcohol by the radiator. The wings of the eagle or frigate-bird-type craft would be essentially mobile during flight in order to modify their surface,

with their proportions [length to width] at least five to one. The tail would have been highly mobile, easy to spread and contract; it would be moved by a compensating system, as would the wings for that matter. There would have been no armament, or very little; the whole payload would be gasoline in order to make long flights. It would have aboard an officer for observation and signaling, and a mechanic to pilot it.

The third category, the line airplanes, would need to be created between the bombers and the scouts, for in fact in their functions they were to be somewhat like both.[5] This category would be composed of two types, the one bat-type and the other bird-type. They would have been designated Avion No. 9 and Avion No. 10. I would have started with the first of these, because of studies already made and the facilities already acquired in construction; but both would have profited from the advantages acquired with Avions Nos. 5 and 7. They would of necessity have had two propellers, driven by a powerful motor, in accordance with the need for a great facility of maneuver required of them. For the same reason, the wings should have been easily displaced in every sense, with changes in surface area and spiral curve.

These airplanes of the line would have become the basic element of the air force. We could have built them in various sizes, but we would have had only one size in each battalion, and perhaps in each legion. Their armament was to consist of bombs, grenades, and arrows, as well as harpoons for use in charges.

We may some day regret having destroyed in the egg this first breed of airplanes. They might not all have seen the light of day, but one must acknowledge that in the 11 years that were lost after Avion No. 3, some of the others would have indeed hatched out.

I will close here this little exposé, all too brief to explain the work we have undertaken but sufficient at least for the reader to have some preliminary idea of it. In the pages that follow, I will touch upon the subject again, but only in the notes concerning airplane construction, in which we will develop as far as we can the techniques drawn from this scientific and prac-

tical heritage, now unfortunately gone, except for the example which was accepted by Arts et Métiers.

What Is to Be Done?

Now, writing these lines in October 1908, I am not sure of the best course. It has now been 11 years to the day since I was at Satory with Avion No. 3, when a single, fateful moment ruined all my plans. Since then the wrecked machine has remained unused, and I can only lament the fate which kept me from doing my duty towards my country, with no one save a few friends understanding what I was about.

At the urging of some valiant aviators who were beginning their own efforts, and to whom the simplest encouragement has been denied to such a degree that it sparked a press campaign, I have just written a letter to the president of the Republic (it is found, reproduced in full—at the end of this introduction).[6] I have reason to fear, according to some indications, that it will not please those who govern us. Yet a reading of it will show that it contains nothing personally aggressive, but simply an intention; that of a Frenchman who wants to be useful to his fellow citizens in the general interest, and this intention is expressed in the form of a petition addressed to the chief of state. Nor can anyone find there anything of politics; if perhaps I have let patriotic sentiments carry me a bit far, never in my life have I been involved in politics.

Oh well, I will only hope for the best results from this endeavor. To begin with, it has found very much favor with aviators, and some have expressed their satisfaction in letters (I have reproduced one of the best at the end of this introduction, following my letter to the president). It is not hard to see that until the present day the public authorities have done practically nothing for aviation; and if my humble effort bears fruit, I will be very happy.[7] Who knows? Perhaps these gentlemen will accord the ten million I have asked of them! Let me only say to them by way of prediction that circumstances will soon require a hundred million, and that will be only the beginning.

I have already indicated my confusion and my uncertainty. Now, in the present state of affairs I have to ask myself a ques-

tion. I have prepared—as I indicated earlier—notes relating to military aviation which I intended to be used in the first courses at the school of military aviation, whose foundation I have so desperately called for. And now, alas, it appears that all hopes in this regard have vanished forever. Many of the notes have disappeared; but what should I do with those that remain? Should I publish them? Would it be better to let them disappear as well?

Up until now I have hesitated, held back by understandable scruples. At the outset I thought that, given the extreme importance of its inevitable purpose, aviation would at first have a completely military character, and that in consequence its emergence would come about under the supervision of the state. Now I am witness to just the opposite of my prediction, at least if we judge by present appearances.

It is obvious that sportsmen have taken the lead, and I have decided to join them, in the belief that they in turn may embrace my ideas. Among that group are a number of my friends, and my ties of friendship with them are sincere. I am competing with no one, and my independence allows me to offer what counsels I can through books and through the press; I will be only too happy if those counsels are listened to and prove useful.

So I will make known these notes I spoke of, and I confess that I hope many aviators will take them up. In the following pages they will find the first elements necessary for their training as military aviators, since these notes were to serve as a starting point for the courses in the flying school.

Let us see then, friends! Is the army not something of a sport? A sublime sport, since it defends our country and our liberty!

The first aviation unit has not yet been formed; when it does appear, in whichever country, that will be a significant event for Europe. If it does not take place in France, it will be an insult!

So when the air legions are organized, enroll yourselves. There you will find full satisfaction for your sportsman's instincts while you are carrying out a great duty!

You young officers, above all, take up the new arm! Your career is open, and glory awaits you there!

Let us all work resolutely, ceasing only when we have given France an air force.

And in the mean time, until you have your own general, I will be honored to serve as your corporal, instructor on detached duty. If it suits you, we can adopt as our motto:

Aviation, Fatherland, Humanity

October 1908
C. Ader

Notes

1. The Musée des Arts et Métiers, or Museum of Arts and Crafts, located in Paris (editor's note).
2. For bomber Ader uses the word *torpilleur,* and for the bomb he uses *torpille.* These terms, of obviously naval inspiration, were still being used on the eve of World War I; among aviators the term *torpille* lingered for a while after the war (editor's note).
3. Ader believed that the lift of an airfoil came from its form as a progressively opening spiral; he saw the wing in cross section as such a spiral curve (editor's note).
4. Ader's term, *route aérienne,* translated here as *air lane,* was a natural pathway through the sky, which airplanes would use because of its favorable atmospheric conditions, particularly rising air currents (editor's note).
5. Ader's term *avion de ligne,* like the term *ship of the line,* indicated a broad range of capabilities (editor's note).
6. Letter published in the newspaper *Le Matin* on 12 October 1908.
7. That is to say, October 1908 ["the present day"].

Letters Cited in the Introduction

Open Letter of M. Ader to the President of the Republic

Paris, 12 October 1908

Dear Mr. President,

I ask you to pardon a humble pioneer of science for calling your attention to a question considered by all aviators to be a point of national honor.[1] It is on everyone's lips and in every French heart, at once a desire and a conviction: henceforth national defense can be effective only with the support of aviation.

And our young aviators are much discouraged. If only you knew, Mr. President, how wounded in their self-esteem are the members of this legion, plunged in their reflections, bent over their work, waiting feverishly to carry out their trials on airfields placed but meagerly at their disposal; this while experimenters from another country—to whom I give full credit for their knowledge and coverage—come to France to offer their services and find a warm welcome.[2]

Do we need foreigners to teach Frenchmen how to defend their own country in the event of an air war? Will we not even try to find out if Frenchmen are capable of doing such things for themselves?

I believe in my heart and soul that 11 years ago I should have had an award from the nation of a million francs. On my own initiative and before any decision had been made on this award, I declared my willingness to turn it over for use in creating the first school of military aviation. Today Mr. President, with all the energy of a man who has seen a great error committed to the detriment of our country and fears he might see it committed again, I call for this million that was to have been mine to be offered as a national prize to the first French aviator who creates an airplane carrying two officers and capable of flying several times between the camp at Satory and the polygon at Vincennes, passing by way of Paris (this was the ultimate goal of any experiments in 1897).

In the name of all friends of aviation, I beg you, Mr. President, to propose in the council of ministers a request to the

Parliament of ten million in order to organize a school of military aviation and to carry out the studies and tests which that institution would require. For its part the National Assembly, putting aside considerations of party and uniting in a rush of patriotism, will vote the money unanimously.

Then too, Mr. President, you have the young National Air League, with its branches. Its very title is a guarantee of its purpose. Ask for its help, and it will be happy to give it.

Immediately thereafter one experiment will follow another. Engineers, officers, and aviators will quickly learn their lessons, and their ultimate success will be a reward for the efforts of all.

However, if some seemingly impossible fate should bring us persistent failure; if after having exhausted our dedication and recognized the powerlessness of French science; if it is certain that our age-old Gaul can no longer forge her own arms, only then, Mr. President, should the government look abroad.

If you could glimpse in a dream the terrifying sight of a body of enemy aviators bombing a French city! And this body increasing twofold, threefold, tenfold, growing endlessly until it formed a gigantic aerial army becoming that most frightful of nightmares, Paris all in flames! Is this only a dream? It is a fearsome near-reality. It is a fateful hour. All of Europe is going to arm in the air. Hesitate no longer, Mr. President.

And should you dream again, that you stand before history, then what momentous pages are reserved for you and your collaborators in the government? How glorious or how disastrous those pages may be!

May these feeble words of mine reach you and touch your patriot's heart. They ask only that you give to France, through aviation, the security that she so urgently needs. In exchange you will receive a reward beyond words—the gratitude of all Frenchmen.

To my devotion, Mr. President, I have the signal honor of adding my most profound respect.

C. Ader

Letter from M. Henry Farman to M. Ader

Paris, 14 October 1908

To Monsieur Ader, in Paris.

Dear Sir,

It was with great pleasure that I read your open letter addressed to the president of the Republic, which appeared in *Le Matin* of 12 October, and I would like to offer you my sincere congratulations in your splendid initiative, all the more valuable since it comes from the first pioneer of this new science—a most difficult science, but one which has acquired many disciples.[3]

I am in fact one of your most fervent admirers, and I remember with great pleasure that as a child I heard of you and your experiments. I recall that even then I was very interested in your research. I have seen your fine creation, the avion, and very much regret that circumstances did not permit you to give greater impetus to a science then in embryo; for I am convinced that with the help you should have been given, and which you did not receive, you would have succeeded, and aviation would today be in full evolution. So I am doubly happy over your appeal. I think it is the duty of all those who can do so to make our task easier, and the best way to make this arduous task easier is to give unsparingly in moral encouragement, and when needed in financial assistance.

I am eager to see this essentially French science develop fully, and not be outdistanced by rival countries who follow our progress attentively and weigh the advantages it offers.

All my efforts will always be turned toward making this conquest of the air definitive, but in order to do that we must remove all the obstacles that lie in our path. We will achieve our goal thanks to an enlightened protection and thanks to the mutual understanding of all those who make their contribution to this most complex science which is aviation.

H. Farman

M. Ader's Reply to M. Farman

Beaumont, 21 October 1908

To Monsieur Henry Farman, in Paris.

Dear Sir,

Your letter has reached me here and has touched me to the heart. To you, a valiant man among the valiants of aviation, I will say this, so that you may repeat it to your fellow aviators: Do not be discouraged. Yes, you are due both moral and financial support. And it is up to the government, above all, to see that you receive that support, for you are all working for your country. And for this reason, when those who govern us understand, they will give you all that you need.

You are right, the new science is a very difficult one, but the difficulties are not insurmountable. As far as I am concerned, I will do all I can to demonstrate in books and in talks some of the principles of aviation; then Avion No. 3 will itself demonstrate certain of them.

In the meantime, I wish you the fullest success; and I will learn of your achievements with the most lively satisfaction.

Most sincerely to you and with you.

C. Ader

Notes

1. See the newspaper *Le Matin* for 12 October 1908.
2. See my letter to the minister of war of 18 October 1897, in the brochure *La première étape de l'aviation en France.*
3. By a curious coincidence the letter addressed to the president of the Republic carries the same date, 12 October, as the day of the first experiment at Satory. The letter of M. Farman, 14 October, bears the date of the accident.

Military Aviation

These notes were intended for use at the beginning of courses at the School of Military Aviation.

These notes, as already indicated in the introduction, date back quite far; they were made at different times, in random fashion, in the rare moments of leisure I found during my scientific researches and the studies or work with aircraft design and construction. I have transcribed those that were not lost just as I found them, and I ask the reader to overlook their disjointed form and their repetitions.

I have brought them together not by order of dates, for most bore no date, but by order of usefulness, to facilitate a progressive understanding and to bring into prominence the major question which concerns us, which is military aviation. To be sure, not all the things I talked about were to come about right away, but I was convinced that many would come to pass—soon perhaps, and I certainly hope so, when aviation will have found its true path and its machines will have come closer to the guidelines laid down by nature. The reader will find that those things that I forecast so long ago were not exaggerated; others will seek to complete this work and to improve upon it.

Note No. 1

Airplanes

Their Name

I said a long time ago—it was perhaps around 1875—that the term *avion*, used to designate flying machines destined for military use, derived from the Latin *avis*, bird.[1] In light of its origin, the word could enter all languages, and certainly our own. I think it is more suitable than that of *aeroplane*, put forward some 60 years ago by the first pioneers of aviation and justified at that time since it was applied to machines with flat surfaces which could stay airborne by keeping the proper inclination in relation to the horizontal.

Certainly, if these precursors, to whom history can never render too much justice, had had a light motor, steam or gasoline, they would have flown as well as they could. But after numerous experiments, I found that the aeroplanes could never produce more than very limited results, and it is for that reason that I abandoned them long ago.

In the machines that will concern us here, there are no planes, and the parts that sustain flight are on the contrary concave; this has led some people to designate them derisively *aerocurves* or *aerocaves*. Little matter what the machine is called, the essential thing is that it flies. As for me, I continue to use the word *avion*, which I have caused to be known and adopted by many officers who are partisans of military aviation, and we will use this name in the courses of the aviation school.

General Conditions

Whatever category airplanes might belong to, they must satisfy the following general conditions: their wings must be articulated in all their parts and must be able to fold up completely on landing on the airfield, like those of the *Eole* and Avion No. 3—they must do this in order to take up the least space possible in storage. When looked at from front to back,

they should have the form of a characteristic spiral curve, which is indispensable for flight. I am quite assertive on this point; in a note recently presented to the Academy of Sciences I showed that this principle is the real basis of aviation.[2] People at the time even spoke of Ader's Sustentatory Curve, which I found very flattering. But I concede the authorship to nature, where I only discovered it.

During the act of flight, the wings should be capable of being easily moved forward or backward by the aviator inside the airplane, in order to keep or lose equilibrium. When advances in aircraft design and construction permit, the frames will fold and the membranes will be elastic in order to diminish or increase the bearing surfaces at the wish of the pilot. This will be possible in flight, so that he can escape from danger during atmospheric disturbances and during combat.

Whether the power is supplied by steam or by gasoline motors, the propellers, or more properly the tractors, should have their surfaces in spiral form like that of the wings. When the motor is not being used, they should moreover fold back automatically, as was the case with the *Eole* and as would have been the case with Avion No. 4, as well as those to follow. This is necessary so the propellers do not offer harmful wind resistance and do not turn uselessly during the descending glide or while flying in rising currents of air, which are always encountered in very hilly country, and which I have named air lanes.

The landing wheels will be of swivel type and can roll in any direction when the airplane is moved about on the airfield; but the two front wheels may be locked by a strong brake while the rear wheel remains free. This will make it possible to immobilize the machine while it is on the ground and keep it pointed in the direction of the wind.

Such are the essential features to be incorporated into airplanes, but there are other special features for each category of machine—the scouts, the bombers, and the airplanes of the line. We will summarize them here and then explain them in detail when we take up the school's course dealing with airplane design and construction. There will also be a category of maritime airplanes, which are the object of a special note that will need to be added in teaching that subject.

I should say that for practical purposes, as indicated in my introduction, the study and construction of aircraft types should begin with the bomber, and this is what we did, in view of construction difficulties. But such reasons mean nothing as regards instruction in the school of aviation, so I began with the scouts, since these would be the first needed in the event of a war; for that reason they are treated first in the present notes.

The Scouts

The scouts will be designed according to their function. Given the role they are to play and the services they are to perform, everything should be sacrificed in the interest of speed and flying long distances. Their wings will be bat-type or preferably bird-type, long and narrow, with the minimum of surface and hence a heavy load for each square meter. Moreover the wings will be adjustable, so that in flight they can be reduced by a half or a third or even less. Their surface should increase, on the other hand, for landings in calm weather. The concavity of the sustentatory curve should be less than with the wings of ordinary airplanes. The center of gravity of the machine's body should be closer to the line representing the center of action of air upon the wings.

The power plant should be a very strong one. I propose a gasoline motor with four twin cylinders, connected at 90 degrees to the same crankshaft, and operating without a flywheel. I have carried out laboratory experiments which have proved to me that with this arrangement the balance was perfect and vibrations nil.[3] Each motor unit would thus be composed of eight cylinders with 80 millimeter (mm) bore and 140 mm stroke, or in larger size 110 mm x 140 mm, and also with bore and stroke equal, all being arranged as indicated above. We would have used as many of these motor units as needed to produce the necessary power, each of them acting separately on the propeller shaft. However groups of vertical cylinders would also work well, and their lubrication would be easier. And everything should be hollow or tubular, carefully thought out, and light in weight, as were the power plants of Avion No. 3 or those of No. 2, which has not been used.[4]

The cooling of this powerful motor would be done by producing steam around the cylinders; this steam would then condense in a condenser placed on the back of the airplane, in a form like that which can be seen on Avion No. 3. The coolant would then return to the cylinders in liquid form, there to vaporize again. The liquid employed could be a mixture of water and alcohol. But I would give preference to a combined system which would place water around the cylinders; this would be drawn off in heated liquid state or in steam to be cooled in a tubular container. There, through the metal tubes it would make indirect contact with alcohol which, given its lower boiling point, would be sent to cool and condense in a dorsal radiator. In this way the liquid would not freeze in the low temperatures encountered in the atmosphere. This precaution would be necessary even in countries with hot climates if one wanted to reach high altitudes.

The ignition will be double, so that if one spark fails, the other will still be good. There would be two small dynamos, each having a very light battery, for the sparking element with its switch; two circular induction coils with circular cores of soft iron wire; two distributors for the current going to the cylinders, each having its own interrupter; and two sparking devices per cylinder.[5] Everything would have been very light, coming as close as possible to the minimal weight in iron, copper, and lead needed for the current to make a spark.

There can be one or two propellers, but preferably one. The nose carrying the propeller will be long. But there is a serious problem with a single propeller. I recall that during the experiment made with the *Eole* at Satory in 1891, as soon as the airplane left the ground, it immediately began to fly obliquely to the left across the rectangular runway and off of it.[6] Both the motor and the propeller were turning to the right; under the effect of the motor and the resistance encountered by the propeller, the shaft underwent a torque effect which tended to make the airplane constantly lean over on its left wing. Moving the rudder or the wings would have straightened the craft in its flight, but I was surprised by this unexpected swerve, so that I did not have the time or the thought to do this. It is possible to correct this pulling tendency by several means: by

moving the propeller to the left or placing it at an angle, by moving to the right side the weight of the fuel and the water tank, by moving the machine's center of gravity to that degree, by the action of the rudder, or by putting on the back a swallow's tail with a gentle spiral to provide opposition to the propeller. But the best remedy would perhaps be a combination of the rudder with displacement of the line of traction in relation to the center of wing action and the plane's center of gravity. Once this question is resolved, the propeller can have two or four blades, long and narrow with spiral curve and with pitch adjustable manually or automatically, in the latter case by action of the motor.[7]

The wheels for landing and takeoff need to be sturdy, sufficiently large but not too large, and of swivel type. Some elasticity is necessary between the body of the airplane and its landing wheels, some 15 or 20 centimeters, obtained by using springs that would be compressed fully only when bearing the entire weight of the airplane.

The body of the machine will be suited to its function—narrow, well tapered, and closed except for windows above, below, and in the sides so the aviators can see out. It will present only a minimum of resistance to the air flowing over it. It will not accommodate many aviators, only two positioned in tandem: the mechanic, seated in front, is charged with maneuvering the airplane, having all the elements for movement within hand's reach; the officer, in the rear on a swiveling seat, can look at the sky, the horizon, or Earth; he can take notes, receive and transmit signals, and communicate with other airplanes, with landing fields, and with the commanders of armies and fortified places. During daytime these signals will consist of red and white discs that will appear and disappear; at night by red and white reflectors lit by acetylene. They should use the Morse system, with white representing a dash and red a dot, but with their own secret alphabet.

Armament will be nonexistent or very little: linked grenades which will explode when the cord that connects them comes under tension. These can be released by the officer against an enemy scout plane, should he encounter one that blocks his way. The real weapon will be speed.

Thus created, these scouting planes will be capable of great speed and long distances. The difference in the consumption of gasoline per hour at moderate and at high speed will not be very great, while at high speed the consumption per kilometer will be considerably reduced. I estimate that these elite airplanes will easily attain a speed of 200 kilometers per hour, on condition that they not vary much from the principles that I have established and will develop further in the courses of the school of aircraft design and construction.

Here someone may raise an objection, asking who would consent to go up in these machines? Who? Everybody! The scout service will be the envy of all flying officers. With their tanks filled with gas, they will take off for honor and country, and they will delight in making stirring long-distance flights.

The Bombers

The bombers will be powerful engines of war. Their wings, destined to bear various heavy weights, will be relatively shorter, wider, and with more pronounced spiral curve than the wings of scouts; they will be of bat-type, elastic and folding so as to reduce their surface in flight. On the ground they can be completely folded up for storage. The bird-type wings will be taken up later. Mobility and maneuverability will be more necessary to bombers than great speed. Fearsomely armed, they will strike the enemy with terror even in their fall.

If internal combustion engines are to be preferred as power plants in scouting planes, it is not the same with bombers. Here we would use steam as well as gasoline motors. The bombers will no doubt attain great size, and for the larger ones steam, with its flexibility and its limitless power, would probably be indispensable. I will not go into detail here concerning these motors, for this is not the place, and I will treat them further later on. I will only say that this power plant stood a stern test at Satory on the unfortunate day of 14 October 1897, and it was not the motor that brought disaster to Avion No. 3 after an uncoordinated flight of 300 meters; only the violence of the wind and the inexperience of the pilot were to blame.[8] So this type of motor would be produced in numbers,

scaling up the size for larger airplanes. They would have an advantage that would be important in war—that of using alcohol fuel exclusively.

Propulsion will be double, as in the system for Avion No. 3, except, instead of overlapping, the two propellers will be so spaced that their arcs abut, and they will turn in alignment, though in opposite directions. Like the single propellers, they will have the capacity to fold back automatically against the nose which carries them. Such a propeller being driven independently by its own motor, either steam or gasoline, it is immediately apparent what considerable power of movement can be given to these planes.

The outward appearance of the body of the bomber and its landing gear will not differ greatly from that of the scouts, since the difficulties of landing are the same for all airplanes.

The signal system will be the same as that used by the scouts. It is understood that everywhere that ground-signal stations exist, the same colors and the same alphabet will be in use.

The sturdy wings of the bomber will support a powerfully armed body. Within it can be housed a whole variety of devices which I will describe, chosen according to the tactics adopted by the general commanding the air force.

Bombs will consist of envelopes of thin steel or of cardboard, cylindrical in shape with conical ends, filled with dynamite or other explosives which the pyrotechnical industry will provide; no shot or shrapnel would be mixed in, as this would be a useless weight which would be better used by adding more dynamite. The bottom cone would carry on its tip a detonator, which would trigger the explosion only after the cone had been flattened somewhat by contact with the ground. The upper cone would carry four fins that would be prolongations of the cylinder and not exceed its diameter. They would be arranged in spiral fashion so as to make the bomb rotate during its fall and keep it pointed at the ground. The weight of these bombs would vary from one kilo to 100 kilos; they could even reach two or three times the latter weight without creating any problem that could not be resolved. Each bomb would be suspended inside the fuselage, under the aviators' seats in a padded compartment open at the bottom. During combat a re-

lease system will allow the officer to let it fall on the enemy at the right moment.

But the sudden releasing of such a large weight will produce something like a shock that will be felt throughout the airplane, even in its wings. This shock of release must be softened as much as possible; it could be reduced by using a cylinder containing a piston whose connecting rod carries the release mechanism. Air compressed below the piston will be sufficient to resist the weight of the bomb, and once the piston is separated from the bomb, it will find a counterresistance in the elasticity of the air trapped in the upper part of the cylinder.

But I prefer another means that is purely mechanical. The bomb will be pierced through its center, end to end, by a metal tube installed during assembly. A threaded rod, carrying two square-cut threads, will slide easily into the tube. The threads on this rod are progressive; least pronounced at the upper end, they gradually become more elongated until they are nearly parallel with the axis of the rod. The tail cone of the bomb will carry two opposing rollers that will fit the opposing threads of the rod. With the rod fixed to the airplane's frame, the bomb will be suspended on it by the rollers bearing on its threads. Upon release the bomb will begin to rotate, at first slowly, then accelerating toward the bottom of the rod. Since the threads there are almost vertical, the bomb will lose contact with its support with very reduced effect. The brutal shock of release is transformed into a rotary movement that is used to keep the bomb pointed at the ground. I have spent some time on this important problem, and I think I have resolved it. I will touch on it again in connection with bomb aiming.

Ordinary ballistics will have little importance in the fall of bombs; but the speed of the airplane, the wind, and the difference in altitude between the airplane and Earth will all be factors which will have to be carefully observed and fixed to achieve what I call aerial aiming. As a consequence various simple instruments will serve to take rapid measure of these factors. A corrective table with variations necessary from the vertical will be under the eyes of the officer aviator and should indicate to him the advance or delay in the moment of release relative to the objective on the ground he is aiming for. It may

seem paradoxical for me to speak of a delay, while we all accept the idea of an advance. Here is the explanation: in calm weather an advance is necessary, depending upon the altitude of the bomber. When there are winds, a delay will sometimes be made, according to the height of the bomber, and this will happen when the wind is contrary and has a speed equal to or greater than that of the airplane, but if the wind and the airplane are moving in the same direction, an even more pronounced advance will be necessary. In a special note later, the theory of bomb aiming will be better seen.

According to the requirements of military operations, the bombers may carry in addition to bombs such things as fireworks to illuminate the ground during night engagements or to reconnoiter the terrain, and even Greek fire [an incendiary weapon used by the Byzantine Greeks].

Generally these powerful war machines will be supported and protected by the airplanes of the line, so that they can carry out with certainty the heavy and critical destructive tasks they will be given, such as the demolishing of fortifications, railways, and roads through narrow passes. Unfortunately their work will also require them to bomb enemy cities. And how can we expect to avoid such catastrophes? Don't battleships bombard port cities? Since airplanes will drive away or destroy these naval monsters, they may be excused for a few misdeeds of their own!

The great bombing planes will become veritable terrors! I am convinced that their awesome power and the fear of seeing them appear will provoke salutary reflections among the statesmen and diplomats who are the real dispensers of peace and war, and that in the final analysis these airplanes will serve the cause of humanity.

The Airplanes of the Line

The airplanes of the line will be somewhere between scouts and bombers. They will benefit as much as possible from the speed of the former and the strength and the armament of the latter. They will be of several different models and two basic

types; for the time being, there would be only the bat-type, made in two sizes.

The wings will be extendable during flight, and their surface can be increased or decreased at will. These airplanes will be characterized by their agility but will also be of solid construction. To strengthen their framework, both in bat- and in bird-type, I propose to make some of them of metal, following experiments and plans already made. Because these airplanes will be stored in great numbers, their wings will fold up completely with great ease, so they can quickly be placed in underground shelters at their base.

These airplanes will need twin propellers as much as, or even more than, the bombers—in truth they are also bombers. The propellers will be driven by a gasoline engine that is very powerful but above all very flexible. The two propellers will turn independently, and one can imagine how easy it will be to maneuver the plane as the speeds of the two propellers are varied, first to the advantage of the left, then the right. The effect should be such that it should be possible to make rapid turns in a small radius with the airplane leaning to one side at about 65 degrees. These risky pirouettes will only rarely be made; they presuppose wings of very great strength, and these will also be necessary because the line airplanes will be obliged to turn virtually on themselves, especially in combat, to avoid an enemy airplane which knows it is doomed and seeks to make contact—that is, to ram.

The line airplanes, being above all maneuverable, will need special signals to help them keep rank or file in their various flight patterns. These signals will be geometrical figures, dots, or lines of various colors and will be clearly visible coming from the command airplane. Just how these are used we will see later in the courses on practical exercises taught in the school of application. It is understood that this set of signals will be different from those using conventional alphabets for communication with the ground and with other air units.

As is the case with the bomber, the chief armament of the line airplane will be the bombs; but these will be of moderate size, and especially small ones, which will be used in the following ways: in battles between airplanes, bombs will be used which are

suspended on the end of a thin, very strong cable which can be wound and unwound on a drum, and which will be invisible to the enemy. The explosion will be set off when contact is made between the enemy craft's body or wings and a detonator located on the top of the bomb. The cable can then be rolled up again or simply abandoned. Grenades strung together will be the weapons most employed because they can be dropped on the enemy from any height. The cord that links them together could be two or three meters in length. The grenades will spread out after they have fallen a few meters; this spread will be accomplished by the air encountering their surfaces, and they will be designed for this effect. When one of the grenades or the cord encounters an obstacle, an explosion will result.

To attack the enemy on the ground, the line airplanes will use a simple grenade that will explode on contact with the ground or any object thereon. There will also be available a kind of explosive "seed," tiny grenades which will be dropped on the enemy's lines to break up ranks of infantry and cavalry.

The same effect will be obtained by using another weapon. This will consist of arrows made from steel wire. They will be very slender, about 1 or 2 mm in diameter and 10 to 20 centimeters (cm) in length, sharply pointed on one end and flattened on the other with two spiral fins which will make the arrow spin as it falls and keep its tip pointed toward the ground. The weight of the smaller size arrow will be about one gram and that of the largest size about five grams. A line airplane could thus carry 100,000 small arrows or 20,000 large ones in a 100-kilo load. These arrows would be dropped in systematic fashion by means of a hand-operated spreader.

When compared with the large bombs and their thunderous effect, these pieces of steel wire may seem laughable. But I have calculated that a perfectly straight arrow 50 cm long and 1 mm thick, perfectly sharpened and falling from a height of 500 meters, is capable of passing completely through a man; this led me to shorten the arrows.

Then there are weapons destined for the most desperate occasions, which will come only rarely; these weapons will be the grapnel and the harpoon, the latter used in charges. The reader must admit that this will be no work for cowards!

The airplane of the line will be the basic element of the air army. Whole legions will be formed, and these combined will form armies. Whether an air detachment is large or small, the bulk of the force will always consist of airplanes of the line; they will be guided by scouts, and they, in turn, will protect and prepare the way for the bombers if that is needed.

The impressive power of military aviation will not work for the detriment of humanity, as some have not hesitated to assert. On the contrary, compared with the present means of waging war, its effect will be to protect humanity. For example, those arrows that I spoke of earlier will be the least deadly weapon of all, since they will cause many light wounds and few that are fatal; and from the tactical standpoint the result is no less effective, since the enemy is still put out of action!

Let's suppose that in a future war a million men take the field in two opposing armies. This is a figure that if anything may well be exceeded. The victorious airplanes of the line will fly over the enemy lines, scattering small grenades and arrows and forcing his troops to disband; nor can the enemy cavalry resist these aerial grenades. And the artillery, reduced to silence, will find itself only encumbered with field pieces that have lost their carriages. In the end all of the enemy's weaponry—rifles, sabers, and cannon—will have been cancelled out.

Notes

1. This note was written at the beginning of 1898. At that period I hoped that my work would not be abandoned, and I was convinced that the need for the school of aviation would be evident to all.
2. Note of M. Ader subsequently presented to the Academy of Sciences by M. Marey, 31 May 1898.
3. In 1898, after abandoning my work on airplanes, I applied this arrangement of cylinders at 90 degrees to automobile motors.
4. Now this airplane and this motor are at the Arts et Métiers.
5. In 1898, when Ader wrote this note, the modern spark plug had not been invented, though, the term Ader uses, *bougie*, came to be applied to it later on (editor's note).
6. See the brochure *La première étape de l'aviation militaire en France*, 7.
7. I will explain how I arranged for this in the chapter on airplane design and construction.
8. Since I wrote these lines, Avion No. 3 has been given to Arts et Métiers and is to be seen there now.

Note No. 2

Bases

The word *base* is not easy to define.[1] One could say that it will be an aerial port for airplanes. Bases could be found associated with fortified areas and also with maneuver areas in the field. Bases will be of three kinds: (1) permanent, fortified bases, (2) field bases, and (3) mobile bases.

Fortified Bases

Permanent, fortified bases will take on great strategic importance. They will be set up in the proximity of fortresses, especially those grouped into quadrilaterals. In this case the base would be placed in an open place in the middle of the complex. But if this is not possible, a fortified place could be used to defend a base associated with it. And even if there is no nearby fortress, when strategic considerations require the creation of a base, then the perimeter of the base itself and its approaches can be fortified with low-profile works which will protect it from land attack without interfering with the landings and takeoffs of airplanes.

The surface for these bases will need to be at least macadamized or possibly asphalted, or paved with wood. It will have to be kept scrupulously clear, and rainwater will have to run off of it quickly. In anticipation of night operations, which could become as frequent as daytime ones, the base's runways will be marked by beacon fires of special color placed in little holes and covered at ground level by grills. Other beacon fires, of different color, suitably arranged, will indicate the wind direction. But these can all be better replaced by electric reflectors that will light up the whole base or leave it in the dark as tactical considerations dictate. Then, in order to provide a more general orientation, beacons will be placed outside the base to mark the four points of the compass, and these will be visible at great distance from the air. During the day these

signals will be easier to devise; white smoke, carried by the wind, will indicate its direction.

The signals used by the bases will obviously be the same as those used by airplanes, and they will be in constant communication. In the event of hostilities, scouts will carry orders and information from one field to another. Later on, when the nascent science of wireless telegraphy has sufficiently developed and its applications have become practical, it too can be used; my phonosignal could also be utilized.[2]

The personnel will be housed in barracks sufficiently removed so as not to interfere with the operations of the airplanes. But in case of alarm, if the base is attacked and bombed by enemy airplanes, the personnel will need to take refuge in shelters solidly armored on top with plates of steel. The same protection will be necessary for materiel and machinery; the shelters for aircraft, workshops, and depots should all have armored roofs to prevent their destruction.

The loss of this materiel would be very regrettable and very keenly felt, but the installation could still be held if it were not for another danger that could completely shatter it. This danger will, of course, come from the depots, which will necessarily contain great quantities of bombs and gasoline and alcohol, since all these are necessary for supplying the airplanes. The enemy will not fail to aim his attacks at these danger points. To counter these attacks, the magazines will be hidden below ground, accessible only by subterranean galleries, which will turn this way and that in random fashion so that when personnel who use them are on the surface, they will have no idea where the magazines are located. Over the vaults of these magazines there will be several layers of thick armor. In truth, no precaution can be spared to prevent such a great catastrophe.

Field Bases

Camp airfields will be of far less importance than the installations previously discussed; nevertheless, they should be composed of the same elements, but of temporary nature. The runways will need only to be leveled, covered with a good layer of sand, and then steamrolled. The installations for lights and

signals will be the same as for fortified bases, but the airplane shelters, depots, and barracks will be wooden structures. Munitions will be kept only in small quantities and in simple recesses in the earth. The supply of combustible and explosive materials should be delivered as needed from fortresses or fortified bases. As much as possible, these field bases will be connected to the nearest rail lines. If this is not possible, then the army's transportation corps, or a special airfield transport service with airplanes and trucks, will bring in what is needed. The defense of the field base against land attacks will consist of simple entrenchments around the field, manned by troops of the line or engineers.

The placing of these field bases in peacetime will depend on strategic considerations. But in time of war, tactical needs will greatly affect their utility; for that reason they will have only a temporary and relative importance. Should a field base be attacked by enemy infantry or artillery, rather than suffer a capitulation, the airplanes will fly off, the barracks and stores will be destroyed, and the troops and the workers will leave their positions and beat a retreat, joining the first regiment or column they encounter.

Mobile Bases

Mobile bases will follow the movements of the army corps. Their essential characteristic will be rapid assembly and disassembly. The landing strip will be covered by a flooring made of wooden panels. These panels will fit together so that they will not come apart as airplanes roll over them. They will be as large as possible while still being manageable and transportable. They might be made the width of railroad flat cars so as to fit into them; when they cannot be moved by rail, special carriages and trucks will move these panels.

The airplane shelters will likewise be of a knockdown type and will be transported along with the runway panels. As for officers and men, they will be housed in tents.

When airplanes suffer damage, large, specially designed vans will carry them with their wings folded back, either by road or by rail. Other vans will follow the bases to keep them

supplied with food and munitions. Of course, accessories such as the lights and signals that were indispensable to the functioning of field bases will also be found on the mobile ones.

It would take too long to surround the perimeter with entrenchments, so there will be only an enclosure made of branches and boughs which can be obtained in the environs by requisition.

A runway made simply of pounded earth will not be sufficient, especially in rainy weather, and while the wooden panels are satisfactory for landing and takeoff, they have the disadvantage of requiring the transportation of a heavy load of wood. For this reason the facility should be as small as possible; perhaps it might suffice to have a circular wooden runway of suitable size with a center of hardened earth. And in fact I will show later that landing in circular fashion with very short radius will be possible.

As soon as everything is ready at a mobile base, a telegraphic order will be sent to airplanes that are being held at a field to the rear telling them they can now land at the new base. It should be possible to set up a mobile base in a morning and then take it down in the afternoon if there is urgent need for it to be moved. Every change in the position of mobile bases will always be communicated to all the other bases participating in the campaign. Base commanders and officer aviators will put them in their daily orders, so that no plane will head in a false direction with the bad consequences that could result. I am supposing that for practical purposes the mobile bases and their airplanes attached to an army corps will be about 25 to 50 kilometers apart.

Notes

1. I have used the word *base* to translate Ader's term *aire* though *aire* implies an expanse of flat surface. Ader's use of the word rules out translation with the word *field* (editor's note).

2. At this time, about 1895, people were just beginning to speak of wireless telegraphy, and then only in scientific journals. Only later would it acquire the importance it has today.

Note No. 3

Naval Airplanes

Air is, after all, everywhere, and if on land we know how airplanes should return to Earth, what about the sea? The constantly growing power of the navy, the possibility of having a fight against a battleship, seem to present us with an insoluble problem. Yet if we cannot hope to destroy a battleship at one stroke, yet I still think it will be possible to do much damage to it at first blow, and even to sink it if the attack is carried out with a sufficient number of airplanes. I foresee, as I explained regarding the armament of bombers, the use of a large bomb of 100 to 200 kilos, and it remains to see how it could be used effectively against warships. If it were a case of attacking a squadron of enemy ships in the waters of France or one of her allies in sight of land, then the task is easy, since the planes could land and load up with bombs on bases near the coast. But it would not be the same thing on the high seas; thus an airplane-carrying vessel is indispensable.

These vessels will be constructed on a plan very different from what is currently used. First of all the deck will be cleared of all obstacles. It will be flat, as wide as possible without jeopardizing the nautical lines of the hull, and it will look like a landing field. The word *landing* is probably not the term to use since it occurs at sea, so I will substitute for it the word *boarding*.[1]

Naval airplanes will be distinguished by several features. The front wheels will be straight, of small diameter, and very sturdy; they will lock automatically on boarding, at first contact with the deck. The third wheel in the rear will do the steering. The back of the airplane will be opened at will in order for the aviator to save himself if the airplane falls into the sea. Possibly each aviator will wear a pneumatic belt and jacket, so that he can get back to the surface and keep himself there.

The speed of these ships should at least be that of cruisers and even exceed it in order to escape from them. To achieve this they will use triple-expansion engines of the most highly developed type. The boilers will be essentially made up of tu-

bular elements and can be installed in very light weights. I would not even hesitate to apply to them the principles of steam generators for airplanes. Ordinary coal would not be used in their fireboxes but would be replaced by coke or anthracite to get rid of any smoke. The stacks, built in telescoping sections, would be erected above the deck for ordinary steaming but would collapse below the deck and leave it free during air operations. At that time the combustion gases would use an auxiliary stack which would divide in two, leading toward scuttles which vent on the port and starboard sides just under the deck, as far astern as possible in order to take away the noxious and unpleasant odor of the escaping gases.

The opening through which the stack would be raised and lowered would be closed by means of a cover in order to provide a smooth and uninterrupted deck surface. In the case of an engine breakdown at sea and far from friendly ships, jury-rigged masts would be very useful; these could be raised and lowered through holes in the deck that could be opened and closed, as we saw in the case of the stacks.

Of necessity, the airplanes would be stored below decks; they would be solidly fixed, anchored to their bases, each in its place, so they would not be affected by the pitching and rolling. Access to this lower deck would be by an elevator sufficiently long and wide to hold an airplane with its wings folded. A large, sliding trap would cover the hole in the deck, and it would have waterproof joints, so that neither rain nor seawater from heavy seas could penetrate below. Nearby would be the workshop of the aviation mechanics charged with repairing damage and keeping the airplanes always ready to fly. Not far away would be holds for provisions and munitions.

As I said earlier, the flight deck would be free of all obstacles. I should add that bulwarks should be set at a good height for the double reason that waves must be kept from breaking over the deck and airplanes must be kept from falling into the sea in the case of a faulty maneuver. The port and starboard bulwarks will be stationary; those at bow and stern moveable. When an airplane takes off, the area forward should be completely free; but when a plane boards, the stern should be free, and the foredeck well closed off.

Taking Off and Boarding

When there are hostilities, even before general quarters is sounded in the squadron, an airplane should be held ready in steerage, always ready to take off. During combat the deck will be clear, the forward bulwark down, and the ship smartly steered into the wind. The airplane will be positioned on the stern. Two launches, one on each side, will be manned and ready for lowering into the water. The aviator, officers, and mechanics will be at their positions, dressed in their pneumatic suits. Calm and determined, knowing that their lives and the lives of others depend upon the precision of their maneuvers, they will await the order "go!" sent by megaphone, siren, or signal flag. These imposing departures will always be moments of supreme emotion felt by all, both aviators and others who are present.

Once air operations have ended, the airplane will return to the ship it is to board. Once they are in sight of each other, they will exchange signals; the aviator will be told that all is in readiness for receiving him, and the airplane will begin its maneuver for boarding. The ship will be headed straight into the wind, the stern clear but a padded bulwark set up forward in case the airplane should run past the stopping line. The deck will be clear, with crewmen standing by to port and starboard. The launches will be in the water—one ahead of the ship, the other following it—ready to save the life of any aviator who misses the deck. Then finally, flying low and straight into the wind, the airplane will come over the stern at a height of one or two meters. At this moment, with power shut off and front wheels locked, it will touch down on the deck and slide to a stop. Thereupon the ship's commander will receive the aviators and will not fail to convey to them his admiration.

To fly off a deck and return to it seems today an act of foolhardiness; the concept of it hasn't even been worked out. But with some practice and the help of some reasoning, this maneuver will surely become an easy one. One might think that in a dead calm it would be very easy to do and that wind would make it more perilous. Just the opposite will be true: in a wind, even a strong one, the airplane will drop gently to the deck with no skidding or very little. When it is calm, boarding

will require almost the entire length of the deck. There will always be the possibility of creating a head wind by putting the ship in motion, but only rarely would its position in a squadron permit this. The operations that the naval airplane will engage in will consist of information sent by signal on the movements of the enemy fleet, but above all its function will be to observe the most menacing elements and to attack them with bombs, either alone or with other airplanes that have joined it.

Bombs

The bombs will be similar to those described earlier and will have in addition a mechanism which will make them explode underwater at various depths.[2] Though nothing will be changed in the progressive release system and though the bomb will still have a detonator on the top of its nose cone, it will also carry on its tail cone a flat disc to which will be fixed two series of telescoping tubes, these fitting into acuities built into the body of the bomb. As a consequence, when the disc is detached and moves upwards away from the tail cone, the telescoping tubes will be pulled out, much as a spyglass is extended. If we conceive that the last tube leaving the bomb will set off the explosion, then we can see that when the bomb enters the water, the disc will remain at the surface, held there by the resistance of the liquid, while the bomb continues to penetrate and to explode at a depth regulated in advance by the length of the extended tubes.

Besides these bombs, others will be made that are beveled on their lower part, with the bevel on one side only. When these drop into the water near a battleship, the angle will make the bomb go under the vessel, and sliding tubes will determine the depth and the moment of the explosion as described above. But understandably with these bombs there will be no rotating motion so that they do not turn in their descent and so that the bevel will always be facing toward the ship.

The naval aviation officer will have powerful weapons at his disposal. He will have only to direct their trajectory so that they drop as close as possible to the vessel he is aiming at, so that

they will strike its vital parts from under the surface. Similar bombs dropping on the deck and exploding on contact will cause great destruction.

Notes

1. Ader's term *abordage, boarding,* never gained currency. For a landing on the ground, the French use the word *aterrissage,* while a landing on water is called *amerrissage* and one on a deck is called *appontage* (editor's note).

2. Ader's use of the word *torpille* for *bomb* has already been noted. While some early writers used the term for a guided bomb or missile, Ader used it for a bomb that was merely dropped, whether on land or at sea (editor's note).

Note No. 4

Vertical Artillery

On land, bombers moving through the air will render all present positions untenable, whether they are fortified or in the field. The creation of special artillery will be required as well as profound modifications in fortification.

The Field Piece

The field piece will go from a weapon fired horizontally to one used vertically. It will swing near its center of gravity on two very strong ball-bearing movements or on sturdy rollers. It will be possible to point it easily in any direction, above all the vertical one, which will be the most used. The carriage will be mounted on four wheels, the forward ones carrying the trail. On the center of the carriage will be a large, round base plate which turns on rollers and will carry the mount with its bearings. The cannon will be placed thereon, its movement being controlled through levers and cranks.

Aiming will be done with the aid of a guide of parallelogram shape, mounted on the cannon's barrel. Let the reader imagine that the bore of the cannon forms one side of the parallelogram and the guide represents the opposing side; the circular base plate will be the third, bottom side, and the top side will be formed by a rod running from the cannon to the guide with articulation at the four corners of the parallelogram. The guide should be about two meters distant from the cannon, perhaps even more, this for the convenience of the person doing the aiming. The trajectory of the projectile will vary with the inclination of the barrel, and for this reason the sighting will automatically be corrected by the parallelogram itself, as two of its sides become unequal; it will be a kind of sight adjusted by the angle of the cannon barrel itself. The alteration of the parallelogram will be so calculated that the trajectory will always be in proper relationship to the line of sight at whatever angle the cannon is pointed.

At the bottom of the guide where it is attached to the base, there will be a horizontal mirror reflecting the guide and the target, in this case an airplane in flight. When the two are lined up, the artilleryman will fire. The effects of recoil will be compensated for by great strength in the moving elements of the carriage and by damping the shock with techniques already in use.

Fortress Cannon

Vertical cannon used by fortresses and by the navy will be based on the same principle as those for field use, except that wheels will be omitted and the mountings will be of fixed type. Very powerful cannon will be constructed which will be able to fire very far and very high in order to hit enemy planes in all directions and at all heights. The up-and-down movements of these great cannon will require considerable mechanisms in order to aim accurately and quickly, for this will be much more difficult to accomplish than with field pieces.

Projectiles may be solid or hollow; the former may be quite elongated and made of lead inside a steel jacket and resembling in form rifle bullets. In this case the barrel would be quite long and the caliber small, with a very strong breech, in order to burn the strongest powders. Their range will be considerable, but their effects will be simply piercing the target. The second type of projectile will be like a shell, set to explode by means of a timing mechanism, a fuse, or some other device, the explosion taking place at a height calculated in advance. The range will not be so great as with the solid projectile; on the other hand, its effects will extend over a greater area, with each shell fragment offering one more chance to hit the objective.

I should add that, despite the high degree to which these weapons are perfected, they will but rarely hit their objective. How can one aim quickly and accurately the ponderous mass of such cannon at an object that is continually moving? Yet, the value of this special artillery will soon be undeniable since it will keep enemy bombers at a distance.

This new artillery will itself be difficult to defend against airplanes. There is no question of placing armor on top of field

pieces, and it is scarcely possible to do it for fortress cannon. In calm weather it would be possible to use artificial clouds; these are easy to create over a considerable area, as wine growers have demonstrated when they want to protect their harvests from spring frosts. This technique of such modest origin would certainly hamper the airplanes, for with Earth no longer visible, they would have no recourse but to leave. But at the slightest wind these clouds would be dispersed, and with them would disappear the tranquility of the adversary below.

Current fortifications, built to withstand low-angle fire, will henceforth find themselves at the mercy of aerial bombs, and it will be necessary to protect their upper works with armor plate of very thick steel. As for new fortifications to be created, another form, a correct one, must be sought. I have not found it, and I do not believe it will be discovered very quickly. Future disasters and other occurrences will reveal this important secret to later generations.

Note No. 5

Air Lanes

Part One
General Considerations

This is a matter of utmost importance! Military aviators will pay constant attention to atmospheric variations, and this concern will not fail to bring about a permanent meteorological service that can, at any time, inform headquarters and airfields of aerial phenomena as they occur in all regions. But until this solution appears, we will appeal for help of observatories already in existence.

Rain, snow, hail, and storms will become so many obstacles in the air lanes which airplanes will have to pass through or avoid by taking refuge on some friendly airfield. But a simple wind might, on the contrary, have aided them in their trip, on the condition, however, that they had followed certain directions from the meteorological service.

With a simple explanation I can demonstrate the principle underlying the formation of the atmospheric route: each time that the wind blows more or less steadily towards a gradual slope, the atmospheric layer in movement conforms fairly accurately to the irregularity of Earth. If there is a hill with two slopes, the moving layer of air will become a continually ascending current in front of the hill, and behind it a descending current; this has been known to meteorologists for a long time.

A long slope would thus present to the windward side an air lane, allowing airplanes to reduce their propulsion or indeed stop it because of the favorable wind. The leeward side would be a place to avoid. For example, the inclines that run from Saint-Cloud, Suresnes, and Puteaux to Courbevoie, and from Bezons to Argenteuil, and those of Saint Germain and its terraces offer three excellent air lanes that are almost parallel and which can be used with an east wind but not with one blowing from the west. Such examples could be found all over France.

The aviation meteorological service, working with the topographical service, will have prepared a map on which the good air lanes are indicated, as well as the bad or dangerous ones and various obstacles. This map will put the aviator on his guard against any surprises during his flight and direct him to the bases, which are true aerial ports.

These topo-meteorological maps, along with information provided by the observatories, will constitute a basic fund of data and the subject of great preoccupation when questions of strategy and of tactics are dealt with. This does not mean that military airplanes will follow their dictates by an invariable rule; officer aviators will often depart from them, depending on the disposition of the enemy, the intensity of the offensive, and the needs of the defensive posture.

Characteristics of Air Lanes

We have seen in general the advantages to be reaped from a thorough knowledge of topo-meteorology. Now let us look at some specific cases.

Cliffs

These sometimes have a jagged, irregular form, but often they follow a straight line for a considerable distance. In the Landes they take the form of dunes; elsewhere they are low and gently inclined like slopes; or they may be high and abrupt, with the sea gnawing continually at their base and isolated spires of rock standing in front of these. These coasts along ocean fronts can be very useful air lanes, but also very dangerous ones, depending on the vagaries of the atmosphere.

With a good, fresh, offshore wind coming steadily over the smooth surface of the water and striking the cliffs, gentle or steep, as they may be, the flow of air is converted into a rising current providing pleasant and easy flying. Such is the case with the west wind that comes ashore between Dunkirk and Bayonne; with the exception of certain gaps at river mouths and entrances to bays and beaches where the coast is flat, airplanes should be able to fly without using much fuel, and part of the time with propellers folded back, the airplane letting it-

self glide along at low altitude in a constantly ascending current of air. The airplane would be facing out to sea during this flight, but also angled in the direction it was going; it would be oblique flight and would be necessary in air lanes of any kind, save where there was a dead calm.

During violent sea winds that become gales, creating irregular currents and whirlwinds over the irregularities of high cliffs, flying would become a compound of dangers, especially in wartime and in presence of the enemy. The air lane would be very difficult to use at low altitude, and the airplane would have to seek a greater height. And, with offshore winds blowing with the same intensity, or even with less force, the area between the high cliffs and the beach would become a gigantic atmospheric eddy and an aerial precipice of sorts.

Mountains

Long flights over mountainous country in calm atmospheric conditions could be made with relative ease, either by flying between mountains or by flying over them. But as soon as any fairly strong wind appears, the situation will change immediately. Winds in the higher elevations would become whirlwinds around the crests and peaks, while it would still be possible to fly in the valleys. Winds in the lower levels, passing around the mountains and finding outlets in small valleys, would create just as many currents, and these, flowing into the larger valleys, would also offer great difficulties to airplanes. Add to this the fortuitous arrival of snow in the winter, and it would be nearly impossible to make a landing! The considered judgment of aviators would be to avoid this aerial turmoil and venture there only for occasional maneuvers, or in time of war when tactical considerations required it.

Rivers and Slopes

Big, wide rivers enclosed with high banks may qualify as good air lanes, depending upon whether the winds follow them, blow upstream, or blow across them. Moreover, broad inclines often run alongside streams, and the two have a dual

influence in making winds that blow across them into rising currents.

Prominences

On plains and also in oceans there are often isolated masses such as crags, islands that jut out, churches and other buildings, and promontories. Winds that pass over them, from whatever direction, are transformed into rising currents whose effect is felt at considerable altitude. No airplane passing by will fail to use this helping hand to spiral up and gain altitude before flying on to the next air lane that will take it to its landing field. From the strategic point of view, all of these prominences will be positions of great importance.

Upper Currents

Aside from air routes close to Earth, there are higher atmospheric currents resulting from barometric reactions, and in many cases these could be used and even indicated on maps as a secondary system of air lanes. In truth every fairly steady wind at ground level is almost always matched by one higher up which crosses it, or indeed goes in the opposite direction, and appears or disappears with it.

Aviators who reach such heights can profit from such phenomena, following the winds going in their direction and thus saving on propulsion and reaching their destination sooner. Nor would aerial tactics fail to take cognizance of these two simultaneous winds in the upper and lower atmosphere or fail to make use of them.

Cyclones and Whirlwinds

In the summertime, particularly in hot countries, there are phenomena called cyclones and whirlwinds. The atmosphere is heated in its lowest layers by contact with the earth made scorching by the action of the sun. These layers have less density than those above; this much expanded air may sometimes cover vast areas, and it tends constantly to push through the mass of the atmosphere and rise through the colder layers above it. It can do so only by taking on a circular, spiral move-

ment; this can be very violent over a restricted area at ground level, but as the air rises its movement is slowed, and its mass is expanded.

The air in movement in this inverted cone thus creates a current that rises in spiral fashion to the highest regions of the atmosphere. These cyclones are like gigantic elevators for any airplane which would be so bold as to submit to their action, and which could do so without risking the dangers that at first glance seem so inevitable. The airplane could begin far out from the cyclonic action and enter it only little by little, and once within its influence, could stay there to reach high altitude, leaving the area of the cone at any height and at any time. Still, the sudden and unexpected character of these great meteorological phenomena would make them rarely of use, and it would only be on unforeseen and fortuitous occasions that airplanes could employ them.

Quite different are the whirlwinds of more ordinary sort, though they are the same in their basic nature as those mentioned above and are traceable to the same physical causes. They may appear quite often and about anywhere on hot summer days. Who has not seen dust and light debris picked up and carried around in a circular motion? There are also whirlwinds which are not seen and which start up at some distance from the ground. All that it takes for their spiral motion to begin is for a broad, hot body of air to be caught in a cold atmospheric mass and to seek its place in order of density. In certain whirlwinds that form close to the ground, it is possible to see their cone, filled with dust, rise gradually to considerable height still continuing to turn; while at the same time the air at ground level has become calm again. All of these whirlwinds make their influence felt quite high; the light objects they carry aloft provide proof of this, for they may come down again at considerable distance. Certainly there must be times when the atmospheric conditions are favorable, when the atmosphere is filled with these moving masses. Since they leave no trace, they cannot be seen, but they exist just the same.

All of these cyclones and these whirlwinds, great and small, could be a great hindrance to airplanes, or of great help to them, depending on the circumstances in which they occur,

but it would be premature for anyone to count on what is unforeseen. Still, such phenomena will give rise to much serious observation, and from this it may be possible to deduce probabilities sufficiently that tactics can be devised when to use them and to avoid them.

Summary

In sum, and by way of general conclusion, we can state the following: an airplane cannot fly in a horizontal current of air without a means of propulsion.[1] The usable lift of an air lane is proportional to the current's angle of ascent and its speed, less the energy the airplane must expend to stay aloft in horizontal flight.

Part Two
Birds and Air Lanes

It would be impossible to end a chapter on air routes without saying something about the birds, those master aviators all of whose skills are rolled into one—that of flying. In the school of military aviation, I would have insisted that along with the study of topo-meteorology, a course be introduced on the theory and practice of bird flight, chiefly that of the large birds. I would have recommended, especially, taking future aviator officers to study and contemplate condors, vultures, lammergeyers, storks, and large chiropters, on site in their country of origin.

It may be that migratory birds, whose behavior we know only imperfectly, obey something besides instinct, which is generally thought to govern their movements. Ornithologists have known that during their long annual trips they often pass by the same places again; it is also known that young birds that are held captive until their fellows have departed will stay in the country in which they were born. As regards topography, migratory birds know their route in its smallest details and can find it again. But through the habit and the experience of making their trips, they have acquired another kind of knowledge, and that is a complete understanding of these

constantly changing air lanes which have occupied my interest for so long.

Observation of Storks in Alsace

I was able to observe storks in Strasbourg. One of the towers of the cathedral ends in a platform that dominates the entire town and its surroundings. A watch service had been set up to warn municipal authorities in case of fire. Although access to the tower was not usually permitted, I was able to go up there and make my observations thanks to the kindness of the employees there, who remained French in heart even if they were no longer so in name.[2]

Seen from above, the comings and goings of these large, peaceable birds between their nests on chimneys and the marshy countryside were extremely interesting. The father and mother always brought their progeny an ample provision of reptiles and frogs, which they distributed by tossing them to their young, who caught them in their long beaks with remarkable agility.

But the most remarkable thing about these storks was the manner in which they flew back and forth. A few dozen meters from my vantage point was the long, straight ridge of the cathedral's roof, across which blew a fairly strong wind. After the storks had done their feeding, they returned to the lakes and steams, but they did not go there directly. Invariably they flew first toward the cathedral, flying straight into the wind that was blowing across it. Once there they executed a series of turns above the monument; without beating their wings they rose to great height, and then, still gliding, they headed for their destination as though they were sliding down an incline. Everyone knows that when birds fly, feathers are sometimes detached from their bodies; when that happened to the storks over the cathedral's ridgeline, the feathers did not fall, but on the contrary they rose, and far more rapidly than the birds themselves. This is certain proof of the action of an ascending current of air created by an obstacle. When the birds returned to their nests, the way was not so easy; they were obliged to flap their wings.

During another of my observations, the wind changed in direction, and the flight conditions for the birds changed as well. Since the needs of the nestlings had not changed, the mother and father still went frequently for food. The point of departure was no longer the cathedral, for now the wind was striking it lengthwise, and these large birds could no longer benefit from the help of the ascending current, which had disappeared with the change in the wind's direction. Now they had to make the trip by flapping their wings, and I noticed that they used every prominence they could to gain all the altitude they could without tiring themselves, and then glide down. It was, in reduced scale, the same maneuver that they used with the cathedral. At that time the Germans were building a new belt of fortifications outside the old one; one of the bastions was already like a formidable cliff. The wind striking its walls created a favorable current that the storks never failed to take advantage of at each of their trips, executing maneuvers according to the excavations and the heights of the rising walls that were particularly instructive to me. In order to observe them more closely, I came down from the tower and went near the works, installing myself among the building stones; I took notes and made sketches in my notebook.

An officer who was supervising the training of recruits saw me and came straight over to me. He questioned me in German, and I replied in French, telling him that I understood nothing of what he was saying. He wanted to take my notebook, but I hastily put it in my pocket; then he called four men and took me into the tower to see the commandant. I found myself in front of a general officer of stern appearance wearing a dark uniform without braid. He began by warning me in French that in Germany espionage was punishable by several years' imprisonment; he then asked me my name, which I told him. There was in the room an engineer from the Siemens firm of Berlin who was there to install a telephone; when he heard my name he turned around to me. The general officer noticed this and asked him, no doubt, if he knew me. After several exchanges between them, I could understand that things were turning out favorably, and with a gesture I thanked my foreign colleague. Even so, the general wanted to see my notebook.

There were many sketches of the birds I had been studying, but also quite a few notes on telephones. This general smiled, and on this note of storks and telephones ended a situation that could have been very unpleasant for me.

Various Birds

Crows

All birds know how to take advantage of rising air currents, whatever might be the form in which these currents appear, but in this regard the large birds seem to know far better than the small ones. Once in a time of dead calm, during what had been a hot day, I watched a large flight of crows leave the meadows where they had been feeding. They rose in great number very gently until they reached a certain rallying point where they all began to turn about, their wings fully extended and immobile. Little by little this mass of crows took on a circular form as it arose, until it finally became a vast ring, growing constantly in diameter, with no birds in the center. When the crows reached a considerable height where they became barely perceptible specks, they all headed off in the same direction. If they were able to reach such a great height without the least beating of their wings in this circular progression, at a time when all appeared still at ground level, what else could have caused this but a circular current of rising air belonging to a whirlwind?

At Sea

The sea also has its air lanes. When there are light breezes or when there are storms, the wind normally forms waves, which may be gentle or choppy but which are always preceded by an ascending air current. These ocean waves have, in fact, superimposed on them atmospheric waves that disappear into the heights just as those of the sea lose themselves in the depths. To benefit from this phenomenon, seabirds are thus obliged to fly very low. It is for this reason that generally when they are seen at any height they are beating their wings, while when they are low they are gliding over the waves. When there

are no waves or wind, seagulls, for example, do not appear in such great numbers, and they seem to prefer gathering in some isolated bay to rest on the water or even sleep there. The great seabirds are completely at home in high winds and storms; it is said that cormorants prefer such conditions for their fishing, and frigate birds no doubt use them to cross oceans. All of this teaches us nothing very useful for airplanes; for them the sea will always be a great danger. To be sure, they could if necessary fly in the rising currents that come from the waves, but at the least error on the part of the aviator, the wings might get wet, and man and airplane might both be engulfed.

The Condor and the Andes

It would be well worth the trip across the Atlantic to see the wings of the condor, to watch him in his native habitat, that unique air lane, seven or eight thousand miles long, which is the great cordillera of the Andes. There he could be seen soaring to prodigious heights in that immense mass of air that comes off the Pacific and moves up the Andes. The condor would set a fine example for American airplanes of the future, whether they are from North or South America. For this will be the most colossal air lane on the globe, with a strategic importance as great as its extent. The Americans, who don't even know of its existence yet, will not fail to fight over it bitterly. And whoever makes himself master of it, be he from the north or south, will be the master of the whole Western Hemisphere. And no doubt this long and powerful ascending current will also be exploited commercially when one considers how huge commercial airplanes could cover thousands of kilometers at no cost, without burning a drop of gasoline! But let us leave the Americans to their adventurous destiny and return to our own sphere.

A Study Trip to Algeria

The great vultures also merit close study, and this is all the easier since this can be done across the Mediterranean in North Africa. I limited myself to Algeria, and it is there that I would have

proposed taking student aviators. The Atlas Mountains and their lateral chains, their heights, whether steeply or gradually inclined, their ravines—indeed, this whole heavily broken territory which is caressed by gentle winds or swept by more impetuous ones—create a splendid flying area for vultures. Let me relate very briefly here the study trip I made to the province of Constantine in the month of October 1882.

I embarked on the *Ville d'Oran* one evening in Marseilles and arrived in Algiers two days later, early in the morning. After touching there and other places, the ship reached Phillippeville, where I stayed only long enough to take the train to Constantine, where, according to what I had heard, the vultures were most numerous.

I placed myself on the platform of one of the cars in order to see the countryside better in case any vultures should appear. The train went as far as the oasis of El Hamme without encountering any. But as we were approaching some rocky heights where a dark spot marked rather picturesquely a tunnel entrance, I thought I could make out the vague form of a vulture. The big bird was gliding down the side of a cliff as we were ascending a grade, so he was approaching me and growing larger. I was already admiring the great, extended wings when to my great disappointment the train entered the tunnel, and a short time later we arrived at the Constantine station. Then, I was all eyes as I sat atop the carriage that took me across the El-Kantara Bridge that connects the two sides of a deep ravine in whose bottom flowed a stream called the Rummel. Here I hoped to discover some of these great birds of prey, for I had been told they frequented this immense precipice, but the place was empty.

When I reached my hotel, my first question was about the vultures. There was nothing easier, I was told, for the birds were seen everywhere. That gave me better hopes for the next day, and very early I returned to the El-Kantara Bridge that spanned the abyss. From this height I could explore with my eyes the stretch of the river beneath me until it disappeared into the rocks. Then, moving downstream from the ravine, I descended among a series of waterfalls, bathing pools, patches of woods, and natural promenades. It was a splendid, cool oasis, full of charm but also unfortunately full of fever. From there I went back up again, not

without difficulty, in full sunlight and sweating from the heat; then I headed upstream to where the ravine began, near the imposing ruins of a Roman aqueduct. There was also a mill there, and the miller, a very amiable man, gave me all sorts of information about vultures. He had seen many of them and quite often! But as for me neither above the ravine nor below it nor in the middle of it had I seen a single one.

Back at the hotel, the bellboy, who was a former zouave, recommended that I go to a certain place where they left the refuse—the city's garbage—and that I would undoubtedly find a number of the birds there, since they were there all the time. He told me to take along as a guide an Arab rural policeman whose house was on the way. There was a little courtyard in front of the house, then a door slightly ajar, which swung wide open to my touch; immediately thereupon three or four young women burst out laughing, but a frightful old woman rushed at me with a stream of vociferous, unintelligible invectives and slammed the door in my face. A passerby told me that if I wanted to speak to the policeman, who was a Muslim, I would have to go to the town hall, which was not far off. He told me on the way that the road we were traveling was called the Benzene Road, from the name of its first inhabitant, an old soldier of the French conquest; he still lived there, and he now raised pigs. This made him detested by all the Muslims and Jews, and if this did not make him repugnant enough, his establishment was alongside the city dump. But was there anywhere I would not go to see a vulture?

Passing a "roumi" cemetery on my left, I soon came upon the old soldier standing in front of his house.[3]

"I want to see where the vultures are."

"Don't bother, there aren't any today."

"But when will they come, then? I was told they are always around here."

"No. Look I'm not an educated person; but there are some things I know. It depends on the wind. Today it's hot and very calm, and the odors don't travel, but when the wind blows it carries them far away and the vultures show up."

"Ah, very good, very good, I understand. Many thanks."

His reasoning, false though it was, put me on the right track. Clearly the odors didn't bring the vultures, the wind did. So I could make this first conclusion: without wind there are no air lanes. For lack of air lanes the vultures remain on their rocks.

When I got back to the hotel, the former zouave introduced me to one of his friends, also a bellboy, who was accompanied by a rather rough-looking man. The second bellboy told me,

"I will take you to a place called Sidi M'Cid, on the outskirts of Constantine and on the other side of the ravine. It's near a penal camp guarded by some turcos; there you will find all the vultures and buzzards you want."[4]

"Let's go there tomorrow morning."

"Sorry, we will have to wait for the day of a certain Muslim festival a few months off; at that time the Arabs' wives go in large numbers and lay out food for the large birds, in the belief that they will spare their husbands and masters if they are killed in fights or raids."

The rough-looking man had come to offer his services to do anything, anywhere, and anytime. He told me he was a hunter and had no fear of any beast, be he large or small. In fact, he was an out-and-out poacher, and I hired him.

Reflecting on the second bellboy's offer and what he had told me, I doubted very seriously that the superstitious prayers of the Muslim women had been heard by the vultures; they knew nothing about any festival and simply showed up to gorge themselves. So I decided to simulate one of these celebrations and shared my idea with my hunter. He went "hum," and then said "yes," but without conviction.

According to him, a tempting bait would be necessary. He knew where to find it, for he had a friend at the Prado. I gave him 10 francs, and he came back with a donkey and its former owner, having bought the one and hired the services of the other for one and the same price. After we crossed the El-Kantara Bridge, we had a choice of two ways to reach the heights of Sidi-M'Cid; one was short but very steep and rock-strewn, the other was much longer, going around by the hospital and the Jewish cemetery in a very gentle rise. I chose the latter, while the two men preferred the more direct route. They started up, and I soon saw that things were not going as they

had hoped. The donkey's master was in front, pulling on the halter, the hunter was behind, pushing hard, and the donkey in the middle, doing nothing to help, was climbing with difficulty. Though I took the detour, I arrived first; in a little while my companions appeared, all in a lather. We chose the spot for the sacrifice, and the hunter gave the donkey the coup de grâce. Night was falling, and so we decided to return the next morning at daybreak; hoping to find the great birds of prey at work on the donkey, as the hunter had predicted.

The sun had not appeared when we all returned. Not only the vultures were absent, but also the donkey had disappeared; yet there seemed no doubt that this was the spot where the animal had been killed. The hunter and his assistant, fearing they were mistaken, explored the surrounding area and, when quite far off, made signals to me. I ran over there, and to our great surprise we found the skeleton of the donkey, as clean as if it had come from some laboratory museum; the jackals had spent the night eating off it, and in their quarrels had dragged it there.

The hunter, who at bottom was a decent man, was quite exasperated that he had let his donkey be eaten by lowly jackals; he felt we would have to stage a mock ceremony. With the aid of his son, a big, lazy sort, he rounded up some helpers. What a mixture they were! They all showed up in a band, carrying under their arms bundles containing old burnooses lent by a rag picker; these they would put on and try to make the birds believe they were Muslim women. The hunter had gone to the market for a basketful of butcher's scraps, and now everybody headed for Sidi-M'Cid, where we arrived about nine o'clock. The weather was splendid with a good westerly breeze. As soon as we arrived they all stopped to put on their costumes at a spot not far from the penitentiary, near a little rock-built tomb that lay in ruins. The hunter, his basket in hand, held the bait up in all directions to attract the vultures. I didn't see a one on the horizon; then suddenly, lifting my head toward the dazzling sky, I saw at a great height a vague form of pale orange color, bordered with light gray, hanging apparently motionless; it was a vulture. Now, with my eyes more adjusted, I could make out another, higher and almost

invisible, then still others. They were all descending in great circles, and as they approached we could see their wings were rigid, widespread. Soon they were quite near us, showing us their superb form and impressive appearance. Without any hesitation they headed toward the hunter, who threw them scraps of meat. I also tried my hand at feeding them, and though I was not disguised, they came to gobble up the pieces I threw them. Our provisions were soon exhausted, and the vultures departed by the same route, that is heading back overhead by making great circles without the least movement of their wings. Eventually they became tiny dots in space and then disappeared altogether.

I was satisfied far beyond what I had hoped for, but I needed to do better still. My assistants had been too numerous and the food insufficient; all those rags were in fact perfectly useless. The hunter went back to the market, made the rounds of all the butchers, and filled 12 large baskets to the rim. From now on he would bring only his son along with him; the rest of the provisions were carried by some turcos from the post guarding the penal camp, their lieutenant having had the kindness to put them at my disposal.

The next morning, equipped with binoculars and three or four instruments I used to study the flight of large birds, we headed back towards the same rocks. The wind was still blowing from the west, but even more strongly than the day before. The air was filled with light and without a cloud, ideal conditions for observation at a distance or close up. This time the air lane was clearly in existence, the ascending current moving from west to east, coming over the great rock that stood above the exit from the ravine; a few hundred meters further on, where the hillside sloped down, the wind was transformed into a descending current. I set up my experiment so I could see and record with my apparatus every aspect of the bird's flight. The two men were posted, one to the west in the middle of the air route, the other to the east, on the opposite slope; I would move back and forth over the ground, followed by a turco with a basket of meat. With the aid of my binoculars, I scanned the horizon, where I saw nothing, and the heights above that were equally empty. But we didn't have to wait

long. Those hazy specks appeared at great height, as they had the day before. They were not yet visible to the naked eye, yet the vultures had understood from our comings and goings that we had brought them food, thus proving that their sight was better than our own.

Soon very visible, they came down in a group, almost dropping out of the sky in their haste to reach us; in no time at all their numbers had grown so that I was a bit concerned, although I knew that these meat eaters posed no danger to me. I was literally surrounded by them. Their wings almost touched me as they passed with a whispering sound like that the wind makes passing through leaves. It was an admirable spectacle.

The hunter wasted no time, and the vultures rarely missed the scraps of meat he threw them. It was he who had been placed in the air lane, and I noted with satisfaction that at his position the vultures were very numerous. They carried their prize up quite high in the air, then once they had swallowed it they dropped down on him to seize another; all of this was done without a single beat of the wings and with an astonishing facility of movement. This was the evident confirmation of the air lane. The hunter's son was no less busy, but the birds refused to go to him, and those who did venture that way, drawn by his full basket, turned back without taking anything, but with some labored flapping of their wings. This was an expenditure of strength that they make only rarely, and in cases of emergency or danger. This was all because the young man was in the descending current, the very opposite of an air lane. This observation was no less important than my earlier one.

In order to be more certain and to test these two conclusions together, I had the young man change place and move nearer his father. The crowd of enormous birds followed him and his basket was soon empty. Then, a little while later I had both men move down the slope, where the son had been earlier, tossing food out to the vultures as they went. The birds took the food quite readily, but gradually their eagerness subsided, and they remained suspended in the air, turning about at a certain height which increased as the food bearers descended. When the men reached the bottom of the slope, both they and the birds remained in the same position, the former offering food and the lat-

ter no longer taking it. Then I had the men go back to where they had started, and the same sort of thing happened except in reverse sequence. The birds all descended again; during the entire time they never left the air lane. Wasn't this the conclusive, emphatic proof of its existence?

When the baskets were empty, the party ended. The vultures and buzzards immediately made their departure. Slowly they began to make those interminable circles, and by these turns and without a single movement of their wings, they succeeded in attaining great heights. One could make them out when they had grown quite small, scattered about in the light of the setting sun, and though they were very high now, they mostly followed that winding chain of great ridges which was a prolongation of the rocky masses along the ravine and also a continuation of the air lane. Then, through my binoculars, I could see nothing more.

During that same splendid day, I was able to make some use of my instruments and gather some useful information that I will talk about later in these notes, when I take up the matter of airplane design and construction. I don't think it is possible by description alone to convey to others the amazing scene I witnessed, so I would have proposed taking the students of the School of Aviation there, and having the scene repeated for them; not only would they have learned about the flight of large birds but also about air lanes.

I would above all have warned them against a great error, for at that time many believed that flight was a kind of sailing, and to that end had developed some erroneous and fanciful theories.[5] I have never been a partisan of this notion, for I have always taken as my basic premise this immutable law of mechanics: no work can be accomplished save through the use of a corresponding force; and since this would apply to the action of gliding, I came to see this force in obliquely ascending currents. This led me to establish the existence of air lanes, then to their utilization by large birds in order to avoid the fatigue of flight by moving the wings. And since these birds make such good use of them, airplanes in turn could do the same.

Algeria has a distinctive feature that will be important in the future. Its territory is crisscrossed by great air routes in which

military airplanes could fly easily and with economy. These could be used by France to hold on to this part of her territory, should she still have it then.

Notes

1. In other words, aerial sailing is impossible.
2. Alsace and part of Lorraine were lost to Germany as a result of the Franco-Prussian War of 1870–1871 (editor's note).
3. The Arab term *roumi* was used in nineteenth century Algeria to designate Frenchmen and was apparently a corruption of the word *Roman* (editor's note).
4. A turco was a native Algerian soldier (editor's note).
5. In Marey's important and instructive book *Le vol des oiseaux* (1890), the reader will find authors who treat this matter of sailing.

Note No. 6

Schools of Aviation and Airplane Design and Construction

Land armies and navies could neither be created nor survive without the help of their special schools of application.[1] The air army would have needed such institutions as much as the services mentioned above, and possibly even more, since it would have been created all at once. It would have needed its school of aviation to train officers, and its school of aircraft design and construction that would have produced engineers.

Already at that time many young officers from all the branches, and especially from the engineers, would have dedicated themselves to the study of the new area and could have been ready to pursue careers there. The two schools would also have received a large number of the top graduates of the Polytechnique, the Centrale, Saint-Cyr, even the Marine and other advanced schools.[2] What is more, admission by competitive examinations would have brought in a crowd of young men who could have been divided between the schools for aviators and for aeronautical engineers according to their aptitudes; this would follow the system used in the Navy, where some are designated to sail ships and others to build them.

These schools would have been under the minister of war, but my belief is that they would not have remained there very long. The importance of the new weapon would have grown so rapidly that it would have required a special ministry, and the creation of a ministry of military aviation would have become certain.

The control of teaching would have been confided to a general, with the first professors chosen among those most specialized in such subjects as aerostation, aerodynamics, and meteorology, who would have been willing to give up old theories and embrace new sciences relating to aviation, teach them, and even extend their limits. People like that I knew where to find. Obviously the school would have had its difficulties at first. But with the aid of the founding professors and my own previous experience, we would have succeeded in

training others younger and newer to the field than ourselves, and these in turn would have trained others. Teaching organized in this fashion would have been successful and would soon have been producing good students.

In this I was not mistaken; a corps of officers could only have been formed with this young element well oriented in their career, highly trained, and possessed of agility and of a courage that could stand any test. The engineer officers would not have had to meet these same requirements; in their character they would have been more levelheaded and reflective, and in their case age and physical qualities would not receive the same consideration. They would have been required to have a complete grounding in science and a thorough knowledge, both theoretical and practical, of all aspects of airplane design and construction.

Program of Studies

School of Aviation

Topography;

Meteorology;

Air lanes;

Topo-meteorological maps;

Essentials of aerodynamics;

Bird flight;

Trips to the habitats of large birds;

General makeup of airplanes;

Bases: various types and their organization;

Vertical artillery: ground defenses against the enemy in the air;

Airplanes: flying and maneuvering them;

Schools at company and legion level;

Pyrotechnics;

Armament: bombs, grenades, etc.;

Aerial gunnery: theory and application;

Formation of air armies;

Command: supreme and subordinate;

Strategy: air, land, and sea;

Tactics: air, land, and sea;

Plans: air, land, and sea;

Signals: theory and practice; and

Administration, logistics, etc.

School of Aircraft Design and Construction

General theory of air resistance, practical demonstrations;

Aerodynamics specific to flying machines, theory, and practical demonstrations;

Study of the spiral curve of sustentation in various types of large birds;

Anatomy, wing structure of large birds;

Scientific fieldwork, study on site of the flight of birds with great wingspan;

Topo-meteorology, air lanes, effects of obliquely ascending air currents, ways of flying in them;

Mathematics specific to airplane design and construction, algebraic and graphic calculations combined;

Resistance of materials, study of their elastic qualities, their use in airplane construction and design;

General studies and projects;

Development of the curve of sustentation for airplanes;

The construction of aircraft, framework, and covering;

Special mechanisms for movements of wings and body;

Mechanisms for propulsion, motors, and propellers;

Construction techniques, fabric, and metal;

Armament of airplanes, employment of weapons; and

Signals, lighting, etc.

This program was the one I had foreseen; later it would have been modified and above all expanded as new discoveries came to enrich the field of aviation science.

(In the sad pages of *La première Etape de l'aviation en France* the reader can see how important to me was the creation of these institutions, whose embryo already existed in very real form in my laboratory. When I wrote in December 1906, the person chiefly responsible for abandoning the project was still alive; now he is gone and I will refrain from attacking his memory.)

Alas, how large and flourishing these two schools would be today! How many heroes and how many savants they would have produced for the defense of our country!

Airplane and Armaments Plants

After the schools, the need would have been for manufacturing establishments. They would have had to be large and placed here and there around the country and built as much as possible with consideration for topographical factors, so they would be shielded from attacks from the air or by land. To this end they would also need to be protected by fortifications.

Here would be the aircraft shops where whole airplanes would be built; here also would be produced material for airfields, special instruments for use in connection with air lanes, bombs ready for delivery to munitions depots, et cetera. Storage facilities nearby would have stocked reserves from the products of the workshops. On a well-built airfield, newly constructed airplanes would have been subjected to trials and tests.

Budget

I made a rough estimate of the costs of organizing the first air army, and I list here the principal items in round numbers.

	Francs
500 to 1,000 fully equipped scouting and bombing airplanes	100,000,000
Munitions	10,000,000
100 air bases, permanent, fortified, field, and mobile	30,000,000
Buildings, barracks, arsenals, storehouses, equipment	25,000,000

Airways service installations	5,000,000
Schools and their materiel	5,000,000
Ground defenses against enemy airplanes and omit vertical artillery	10,000,000
Naval aviation	5,000,000
Unforeseen expenses	15,000,000
TOTAL	**205,000,000**[3]

This was a very great sum! Later it would grow even larger. But then national defense is a very great matter, since upon it depends the nation's existence!

I should note in passing that 10 battleships and 10 cruisers would cost 30 to 50 million francs apiece, so only 20 ships would cost 800 million. That too is a very great sum!

It remains to be determined which of these two armament schemes would have rendered the greater service, assuming that each was used to maximum effect. Only the unfolding of events could tell us, but it seems to me very dangerous to simply await that verdict.

These expenses I proposed are in no way excessive when compared to those of the war and navy departments. Moreover, they would permit the creation of a first air army of respectable size.

The annual budget for military aviation when completely developed would not have reached the fantastic level attained by the sums currently dedicated to national defense. On the contrary, it would have introduced considerable savings; to see this in tangible form, let's suppose that a great part of existing armaments would have been abolished as having become useless, and that the total budget for military aviation would only have been half that of the war and navy departments combined. One can see right away that the savings would have reached perhaps a half billion francs.

But, it would no doubt have been impossible to cut the present budget for fear of weakening our national defense. So with the other half of the budget, we could have maintained 4,000–5,000 airplanes along with all they required by way of personnel and material. This would have constituted a colossal air force that no enemy force could have resisted unless it were equally large. And by now our advance over the other powers

in military aviation would have been so great that such an eventuality would have been impossible.

Notes

1. This note and the preceding one and some others which follow were assembled and revised at the beginning of 1900; I hoped that the aeronautical congress that was to take place would give some impulsion to aviation, and I had the idea of presenting these notes there and others as well. But my hope was vain. I presented only a single note, very general and of no great importance.

2. These are the most prestigious technical, military, and naval schools in France (editor's note).

3. These figures are in French francs. At the time Ader wrote, the franc was worth 20 American cents (editor's note).

Note No. 7

Air Strategy

Preamble

Two basic considerations operating together seem to dominate this new branch of the military art: first, the topographical situations of the area involved, then the proximity or distance of air lanes in relationship to any point on land or in the air that is to be defended or attacked.[1]

Leaving aside the question of topography, whose basic elements we already understand, and which can be found on any staff map, we can perceive the difficulties, even the impossibility of having right away maps of the air lanes; I have already indicated elsewhere the imperious necessity of having them as soon as possible. For want of them I am obliged to limit myself to the generalities of strategy, adding details here and there when they are relevant to our discussion. I will simply relate how I understood this subject then and how it appears to me now.

Later—and I don't think I would be wrong in saying before long—air strategy and its handmaiden tactics will undergo considerable development. These sciences will take a prominent place in the realm of military erudition and will require great intellectual effort on the part of their practitioners. They will leave far behind them those same sciences as they relate to land and sea warfare. Though the latter required centuries to take form, our new sciences will come into existence and surpass them in a matter of a few years.

I should note in passing that the older strategy will accept changes in its ways only with reluctance; each time a new weapon has appeared, strategy has had a difficult time incorporating it. We know relatively little about the Middle Ages, when strategy must have been very simple. The older weaponry was made up of such things as pikes, javelins, lances, arrows, and slings. Gunpowder made them disappear, though not all of them, since we have retained the breastplate,

the saber, and the lance. We know more about what has happened in more recent times and in our own era. Under the Empire the musket firing the round bullet and the cannon firing the round ball ruled supreme. At Magenta and Solferino, where the Austrians fought with cannon firing round ball, they were defeated by the French who attacked them with rifled cannon and shells. At Sadowa the Austrians had retained the old musket; they were crushed by the Prussians, who were armed with the needle gun. At Sedan the French used their rifled bronze cannon and were beaten by the Prussians, who from a long distance off showered them with projectiles from their breech-loading steel cannon.

And yet, despite these harsh lessons, after the disasters of 1870 we saw our military figures persist in retaining the bronze cannon, and they barely accepted the idea of modifying it to allow for breech loading. To be sure, after a few years they did face up to the problem of renovating the artillery and gave it steel cannon. But it was too late; earlier policies had left a legacy of harm and benefit—harm for us and benefit for our enemies. Steel in the hands of the military had created German unity, and steel in industry maintains that unity.

Will this succession of errors, which was the result of incompetence and routine-mindedness, be continued as military aviation? Let us hope that in the future succeeding stages of its organization will not be afflicted by the reverses that attended the first stage.[2] It will be up to our strategists who have freed themselves from the old ideas to overcome all the forms of resistance.

What will become of frontiers in the course of the century? If in comparative terms, we talk today of frontiers being within cannon range, we can foresee that later it will be a matter of their being within airplane range; thus the law of the expansion of large states at the expense of small ones will continue to hold sway until it produces the unification of peoples. Military aviation will be the crowning achievement for this great event. Will it be in the interest of liberty or of despotism? Those who rule us should think of history and reflect on the pages they will occupy there, whether those pages will be laudatory or filled with bitter commentaries.

France

Paris? It has a bad topo-meteorological location. It's too close to everywhere. As the airplane flies, Paris is 180 kilometers from the Belgian frontier, 275 from Metz, and 150 from the Channel cliffs. And these distances could double, triple, or quadruple in aerial terms; or be reduced by similar proportions, depending upon whether winds were favorable or unfavorable, and upon whether the air lanes were active or dormant. If ever a city needed to be defended, it is our capital, placed as it is between two fires, so to speak: Metz and London.[3] It seems to me that two sites located almost providentially nearby are destined to play a preponderant role in the city's defense. They are at Satory and Vincennes, on opposite sides of the city, to the west and east.

Satory

The vast plateau of Satory is little known to tourists, though it abuts Versailles; from the camp there all the way to Saint-Cyr it is sufficiently high to dominate the neighboring hills. It is something of a wild place, deserted when there are no soldiers there. It's a place no one goes to or passes through, save by a little-used road running from the south up toward Chevreuse, and which could easily be rerouted.

The ground is rough and bad in wet weather. On the other hand the wind blows there almost constantly. I should remind the reader that it was there, on 14 October 1897, in very bad weather, that Avion No. 3 met its end in an unfortunate landing after a flight of 300 meters.

This immense natural platform west of Paris would be a strategically unique position for its aerial defense. It can and should contain the whole range of powerful aerial weapons and formidable ground installations in order to render the site impregnable and its air army invincible; for should these be lost, Paris would be lost soon afterward.

First of all the plateau should be completely fortified with bastions and outer works if necessary, along with other defensive systems that the experience and the foresight of engineers may lead them to devise. Besides heavy fortress cannons, there will

be a need for much special artillery to keep enemy airplanes at the greatest possible distance. Should this happen, perhaps these vertical cannons would make it possible for some reserve company of airplanes to come to the assistance of the place.

The whole extent of Satory will be used; it would be a great error to occupy it only partially. A dozen small airfields could be built there for everyday maneuvers, but in addition it will be necessary to organize a central one which would be very large, and divided into two separate parts: one for takeoffs and the other for landings, so that airplanes can leave and arrive en masse and in battle formation. This would be the heart of the installation. Airplanes would be there in great numbers, certainly 4,000–5,000. Line airplanes would outnumber bombers and scouts; they would all be constantly ready to take off at the first alert against an air enemy who was reported to have crossed the frontier heading toward Paris.

Large quantities of supplies of all sorts will be stored in magazines placed underground or at ground level, depending upon the nature of the material stored. Barracks will need to be built, for an organization of this size will require numerous personnel. Finally, all the installations, service organizations, and precautions I have already foreseen and described in the chapter on permanent fortified bases will be incorporated into Satory, and it is understood that they will be on a much larger scale.

Vincennes

Here space will never be a problem, so one can erect as many buildings as one wishes. There will be a complete factory for airplanes and aviation materiel. This will probably be the most important airplane manufacturing center because the resources in labor and supplies can be found in Paris more easily than in the provinces. This installation will be called on to furnish airplanes and other materiel to all the airfields of the north, east, and west of France, precisely those regions most exposed to attack from the air. The manufacturing facility will be the essential feature of the Vincennes base, though this is not to exclude various factories located at various important points around the country; in case of defeat in the north, these

could continue to produce airplanes and materiel to keep up resistance in the center and the southern parts of France.

In large clearings in the forest, which can be further enlarged if necessary, will be located in the administrations for all the services of the air army. There will also be found the training fields, the school for flying airplanes and for the assembly and disassembly of mobile airfields, the exercises relating to the handling of munitions and transport materiel, the use of instruments for operations involving air lanes, and training in such tasks as vertical firing and the release of bombs—in a word, everything that contributes to the training of student aviators. This whole complex will be surrounded by rather high walls. It might not require fortification.

Quite separate from the services listed above would be the strategic position—that is, the permanent fortified base. Less well-situated geographically and meteorologically than Satory because of its location on low terrain and its distance from air lanes, it will at the same time be more exposed to violent attacks that could come from the east. It should thus have defensive means at least as formidable as those of its counterpart in the west, and even more so if this is possible. It should take up all the extent of the polygon at Vincennes and a part of the wooded area as well, to round out the perimeter. A cleared zone, closed to the public and walled by palisades, will be in front of the fortifications. Its walled and bastioned enclosure, its various structures and fields—especially the principal one—will follow the model of Satory. There the air army will be installed in force with a large number of airplanes.

The Watch over Paris

Flanked by its two defenders, Satory and Vincennes, Paris will be well guarded on condition that it resigns itself to being thus protected and that it accepts the sacrifice involved in contributing to its own protection, for it would not be fair to make the nation pay the entire costs. Given the city's susceptibilities and its temperament, which can be provoked by the most minor thing, those who undertake to make Paris safe should understand this new danger and will have no small

task on their hands. Yet Parisians must accept the idea the city could be destroyed in two hours, and that whatever they might do to prevent this catastrophe will never be too much.

Day and night, two-plane air patrols will go back and forth between Satory and Vincennes, passing each other over the city. Sentinel airplanes, relieved every hour, will circle over the chief monuments, the principal buildings, the residence of the president of the Republic, the Senate, the Chamber of Deputies, some of the ministries, and above all the War Ministry. By means of signals, these airplanes will remain in constant communication with one another, with Paris, and with their respective airfields. Fog will not stop them; they will fly above it, and they will then use acoustic signals or other ones that will be devised; indeed during periods of fog, vigilance should be redoubled. Sentinel airplanes over Satory and Vincennes will also maintain a strict and very extensive surveillance; anything suspicious, in the air or on the ground, at Paris or in its surroundings, will be reported immediately.

Espionage

Espionage should be made difficult if not impossible by radical preventive measures. Here, it is to be feared, there will be strong disagreement between the military and the sporting world. Vincennes, so vulnerable because of its arsenal, so reassuring for the protection it will offer to the capital, may prove a serious problem because of its closeness to the city. Oh yes! On Sundays, during holidays, balloons and *montgolfières* [a type of balloon] will be departing; every day the wind blows, kites will go up; nothing will be easier than to take snapshots of the airfield, the arsenal, and to see what is going on there. From this standpoint spies will have an easy time of it. The military and the sportsmen will lecture each other more than a little over the question of whether Paris should be disturbed in its amusements or given over to spies.

Then we must ask what attitude military-aviation authorities will take in regard to sporting dirigibles and airplanes. If they are prohibited from moving about in the atmosphere, there will be endless protests and recriminations. If they are

left free to fly about, the air defense of Paris will be illusory. Subjecting this sport to regulation will give rise to complaints by many people. So whatever decision is taken, it will create a swarm of malcontents.

But some very unfortunate things could happen. We know that bicycling has had its wild cyclists, automobile driving its wild drivers, and we can count on aviation having its wild aviators, its flying fools. These will be a scourge capable of producing all sorts of unseemliness, and perhaps damage, and will be condemned and abhorred in advance by friends of the new arm and of the new sport alike.

Will there not be aero lunatics who, for money, will take a companion fresh from a foreign general staff and fly him over airfields and fortifications, and with the aid of photography prepare very exact plans of all our air defense installations? They could locate the entrances to powder magazines in order to bomb them more effectively later; they could count the number of airplanes on the bases and discover the secrets of the maneuvers.

Who can guarantee that on 14 July some young flying fool will not take it into his head, without the least criminal intent, or perhaps to protest the storming of the Bastille, to play an extravagant prank and drop firecrackers into the streets and thus panic the crowds?

It would probably suffice for people to recognize that such unfortunate things could happen for them to come to some agreement. That will happen if those who govern will show a firm will, strong enough to overcome petty concerns and show each his duty. The new sport could draw satisfaction from participating in military aviation. We have seen privateers and irregulars, those who are voluntarily enrolled for military service, and we could also have an aviation enrollment. By such an institution, the danger of espionage would be reduced if not eliminated, and the air army would be enlarged.[4]

The Provinces and the Frontiers

It is unfortunately all too true that if Paris is vanquished, the rest of the country counts for nothing thereafter. Paris will always be the objective of our enemies, and no doubt the only

one. We have seen that its means of air defense should be proportionate to the danger that threatens it; this cannot be repeated enough. But the enemy must not even be allowed to approach the city, for in the event of a defeat there, the air forces at Satory and Vincennes would only be a colossal, final reserve for the last battle which, if won, would save Paris and France, and if lost would bring total ruin.

The most sensible system of defense will perhaps consist of a chain of alternating permanent fortified bases and temporary bases. These all together will form a very resistant, continuous front running inside our frontiers. These fields will be linked telegraphically by buried cables. In case of mobilization, concentration, or retreat, in the most threatened areas there will be vast temporary fields to receive the victorious or defeated air armies. All important positions on the frontiers will be provided with vertical artillery; since this special artillery can have only limited success against airplanes, it will be best to use it advisedly and to install a few good, large pieces instead of many small ones. Such in principle would be this system of defense, which would vary considerably depending upon whether it was on the south, the north, the west, or above all the east.

Since the southern part of France is less exposed to air invasions than the northern regions, the permanent fortified bases established along the frontiers could be rather far apart, for example 50 to 100 kilometers. In between there would be two, three, or four temporary airfields, perhaps a little further forward than the permanent one.

As regards Switzerland, Italy, and Spain, currently there are not a large number of fortresses, and one can almost do without them, since the Alps and the Pyrenees are natural defenses between neighboring countries. With military aviation the great mountains will no longer be obstacles, and the frontiers will have to be guarded there as everywhere else.

The Atlantic and Mediterranean coastlines will not escape the need to be defended, for enemy airplane-carrying vessels could chose poorly guarded points along the coast to launch their airplanes against our territory. So we would place fortified and temporary airfields not far from the beaches and cliffs; the temporary ones would need to be sufficiently inland

to be out of range of bombardments. What is more, airplane-carrier ships, protected by coast guard vessels, battleships, or cruisers, should always be ready to take their bomber airplanes to the places that have been attacked.

More serious will be the proximity of England across the Channel. What will this great power have as an air force? We will try to determine that later, but for the moment let's consider the worst case, and we probably won't be wrong: Today friends, tomorrow enemies. Be strong, very strong, we are often told by way of advice. If we are strong in aviation, it is the proximity of England that will make us preeminently strong; on the other hand she will not need us to play the same role for her.

The Channel coast along its length should present an uninterrupted line of defense and resistance able to withstand any test. From Dunkirk to Cherbourg and even beyond, the airfields should be side by side or at least very close to one another. The large vertical cannon will find their employment here. It goes without saying that airplane-carrying ships will be indispensable and will accompany cruisers and battleships to act in concert against the enemy in case of hostilities. In the neighborhood of Calais and Boulogne large, well-fortified airfields must be established at all costs, along with carefully concealed underground magazines; large numbers of line and bomber airplanes will be stationed there, ready for any eventuality. Indeed, the 35 kilometers of water that separate France from England will be nothing for airplanes, barely a half hour or even a quarter hour will suffice to pass from one coast to the other.

From Dunkirk to Lille and beyond, the Belgian frontier will need to be carefully watched and sufficiently defended, not because of any distrust of Belgium, but for fear that an enemy air army might find the way open to invade us; it would be so easy to violate the frontiers of neutrals! This first Cherbourg-Lille line of defense would not be enough; should the enemy force it, he should encounter a second and even a third line capable of stopping him and keeping him from moving on Paris. As a consequence these must be created as strong as the first line. Let's not forget that Satory and Vincennes should be considered only as a last-ditch reserve.

Now let's look to the German frontier, which the disasters of 1870 have brought too close to Paris and in an unexpected way to the advantage of Germany, for in that era of misfortunes no one on the enemy's side foresaw military aviation, though had they done so, they could not have done better for themselves. If we had held our frontier on the Rhine, we could have organized an effective air defense. With Metz in Prussian hands, this becomes very difficult; from that stronghold surprises very dangerous for France could come at any moment. Metz will become very menacing; remember that by air she will be only two hours from Paris!

Certainly we must not make the mistake of neglecting any part of the frontier with Germany. Inside that frontier, in well-chosen positions, we must take the same precautions as on the Channel coast; but above all we must prepare to deal with considerable air forces which will not fail to be sheltered in airfields protected by Metz. Unless France wishes to rush headlong to her ruin, she must erect impenetrable barriers against any air army coming from this direction. The least error committed, the slightest mistake in making up the organization of our strategic works, could later turn into an irreparable catastrophe. Thus for my part I can recommend nothing definite, so serious and so delicate is this question. I ask my readers to take note of this restriction, which applies to the whole eastern region.

One can imagine a group of five or six first-class bases set about 20 to 30 kilometers apart in front of Metz, arranged in a semicircle 50 to 60 kilometers across. Such an arrangement would permit the airplanes from the various airfields involved to all concentrate after flights of 30 to 50 kilometers, this in order to act defensively by blocking the flights of enemy machines, or to act offensively by attacking them in the air or on their airfields. Verdun could be used as a support base; in its environs would be placed the reserves necessary for maintaining the forward positions in the semicircle. It would remain to be seen if the German General Staff would accept such a disposition. If they opposed it to the point of making it a *casus belli*—which would prove the system was a good one—the arrangement could be moved back in the direction of Verdun, enlarging the semicircle and increasing the number of airfields within it.

The Châlons Line

This first line of defense near the eastern frontier could never be strong enough, however much it might be strengthened. It would inevitably have weak elements that the enemy could exploit. This possibility would make it necessary to create an absolutely impregnable second line which would serve as a support to the first, which it paralleled, and would so effectively seal off the air lanes that no air army would dare venture there without risking being caught between two parallel forces capable of pressing the enemy between them.

It would appear that Châlons is the place for the center of this transverse obstacle raised before the enemy; its form could be straight or sinuous, and it would be made up of a succession of groups of bases formed into a chain. Each group would take the form of a square measuring 10 kilometers, more or less, on each side, with one of the angles—that is, one of the airfields—turned towards the invading enemy. A chain of groups of airfields formed into a semicircle with its concave side facing the enemy might have certain advantages defensively. Whatever the geometric figures adopted, a group of bases would always afford the airplanes a great ease of concentration.

The Checkerboard

It would be necessary to scatter bases in profusion between the two great defensive lines: the frontier and the great Châlons line. Understandably, most of them would not need fortification, save the most important. They would serve principally for mobilization and for airplanes moving from one direction to another in this country as if on a checkerboard. That's what one might call these aerial way stations spread in all directions; through them supplies could be moved during offensive operations, and they would also assist in executing a retreat in good order in case of a reversal.

In all these eastern regions, which are the most endangered part of France, the air lanes would have great usefulness, and they would be related to all strategic positions, since they would be of real importance, just as land routes are to armies on campaign. The multitude of often steep-sided peaks which run

across the country is known to strategists already in great detail, and their description would be too long, but these will be as so many air lanes which will need to be carefully studied so that they can be entered on topo-meteorological maps. We should not be surprised if later some vertical batteries are placed on these peaks to bar their use during hostilities.

One should be very careful about natural landing places that the enemy might locate and use on the great chalk plains of Champagne and other places. According to the degree of danger, obstacles will be placed on them, or if necessary they will be guarded by vertical artillery. The same remark could be made about roads, where one should take care not to cut the trees. In a word, one must use every possible means to keep the enemy from landing, unless it is with the intention of catching him in a trap.

What plans still need to be made in this defensive organization of the East! All of the preceding, the product of pessimistic reflections all too well founded, presents only a feeble idea of the realities that lie in the future.

England

What will England do? At the outset nothing! Everything will go on as before; commerce and industry will remain the chief concerns of the English people, while the navy and the colonies will preoccupy their rulers. Those among them who oppose a bridge across the Channel, which a single spark and a moment's time could send to the bottom, and those who oppose a cross-Channel tunnel, which a single floodgate could inundate in the blink of an eye, will persist in their opposition for fear of compromising their splendid isolation.

Then military aviation will emerge from behind the veil to demonstrate to Great Britain that the Channel no longer exists, that her countless warships and all her fortresses with their heavy artillery have become useless, that British territory is henceforth open to the winds, and finally that London is defenseless behind all its outer guards and runs the risk of being consumed within the space of two hours. Then our neighbors will all experience a terrible nightmare!

To be the mistress of the oceans and see London, the brain of this immense empire, at the mercy of an air raid! By Frenchmen? No. By Germans? Perhaps. Oh, not that, never!!

Such will be the general outcry in the United Kingdom. England will want to be, and will have to be ruler of the atmosphere. To obtain that position, she will know a feverish activity that has no parallel in her history.

To do them justice, we must concede that the English are ahead of all others in industry and the mechanical arts, and these aptitudes will considerably simplify their task of creating air armies; but every coin has its reverse side. It will be interesting to see the multitude of inventions that will be proposed in the near future, very few of them workable, amongst a mass of worthless projects. Aviation merchants will spring up on all sides as if by magic. Yesterday they were indifferent to the idea; now they are overflowing with enthusiasm. So it goes; the English have money and they need something, and there soon will follow a frenzied hawking of wares.

At the outset, all will perhaps be confusion, with great efforts that yield nothing, but that will matter little. The practical mind of the Englishman will allow him to see with his first mistakes the right way to proceed to ultimately produce an air army before anyone else in Europe. We may fear that someday this power will be an anvil on which France lies exposed, while the hammer to go with it is being forged elsewhere!

The air admiralty—let's suppose it will be called that—will no doubt begin by providing for the defense of the Channel coast along a considerable stretch, probably from the extremity of Cornwall to the coastline along the North Sea, with heavy emphasis on London, and a first defensive line in the narrow seas facing Calais and Boulogne. Fortified bases would be constructed on all the sizable, elevated plateaus near the beaches. The main strategic points in this long cordon of defenses covering the English Channel coast will be made into impregnable positions with armored superstructures and tunnels with concealed entrances containing flying machines and supplies; this will especially be the case with those positions located near rocky cliffs. If the enemy arrives, he will find himself facing veritable Gibraltars sheltering military airplanes.

However, the jagged coastline of the British Isles can scarcely be defended everywhere. Its vulnerability will be great if attacks are made using airplane carrier ships. The problems of the English will be compounded by an all-too-persistent fog which often covers Ireland and Wales, not to mention all of England; perhaps only the far northwest of Scotland will be safe in this regard. With airplane-carrier ships, who knows if this will be the case?

Throughout Great Britain the numerous cliffs, the parallel lines of hills that cross Scotland, the English mountains in the counties west of London, all form superb air lanes activated by frequent winds. These will surely be used for defensive purposes and will be marked by fortified airfields. All the chief heights along these routes, even those in the vicinity of airfields and forts, will be heavily armed to fire as far and as high as possible against invading airplanes. The weapon employed will be the vertical cannon; it will be the defensive weapon preferred by our neighbors, who will develop it to the highest degree of perfection.

The Defense of London

It is easy to foresee that the principal effort of the air admiralty will be the defense of London. Every place in its environs that can be made into a strategic position will receive immense fortified bases, each capable of accommodating an entire air army and all its services.

These defensive units will be self-sufficient and capable of conducting air campaigns. They will be remarkable for the complexity of their organization and also for their cost, which will run into the hundreds of millions; and there could be 20, perhaps 50, of them in the environs of London. This does not include others that would move from the Channel as a second belt to reinforce the aerial barrage.

And what else would the English do? It strains the imagination. If we consider that the preservation of London is the key element, and that they would undertake the most daring steps not to lose it, here is where the situation could become dangerous for France. The fear of aerial invasions will push our

neighbors' distrust to the extreme and could give rise to all sorts of unfortunate complications. They will see spies everywhere, and traveling about in the air will become very difficult if not impossible; as a consequence the matter of espionage will be dealt with very quickly. A single act of Parliament would suffice: "It is prohibited to fly in England."

At the least alarm, because too many airplanes have been seen in the Channel or because anxious lookouts have spotted unexpected maneuvers on the other side of the Channel, a general call to arms might be ordered and even carried out. One can imagine what a spectacle it would be, this immense concentration of armed flying machines! Once the authorities had realized their error, of course, everything would return to normal. And to think that it is not just possible but indeed certain that Londoners will be witnesses to these unexpected aerial mobilizations. Yet this is the way it would be in time of war; and in fact these emergency exercises will give English aviators a decided superiority in flying skills.

And what will happen when London is wrapped in fog? At each moment its inhabitants will think that enemy bomber planes are coming, exactly how or where they don't know, to release over the city Greek fire and Amite cartridges.[5] To keep everyone calm, and also to keep themselves informed, aviation authorities will send airplanes to mount guard above the fog and to send assurances by signals that the upper atmosphere is indeed empty.

In the future of England there are all sorts of question marks, more than for other powers, and this is because aviation will oblige her to undergo the most radical transformations. Formerly the sea was her safeguard; she could stand up to all the other powers and still can; but from now on, she will be with all the others, within the same atmosphere.

Then there is the question of Ireland, which has not been completely resolved and which could flare up again. What things might happen in the future above the fog covering the body of water known as Saint-George's Channel?

Then too, England possesses the islands off Normandy. Will she occupy them in the aerial sense? They are close to France, and indeed they almost touch our coast. Will she establish bases and an air army there? Will she act from fear or on the pretext

that from Normandy an invading enemy could head for the counties of Cornwall or Wales, even toward Ireland, following the line of flight Cherbourg-Cornwall-Munster? The English know that these distances are not very great: from the continent to Ireland it is 450 kilometers, to Plymouth only 160.

I have gone quite far in considering such possible complications in order that France, understanding these, could be on her guard while still remaining on good terms with England, in the belief that this would be the surest way to keep her friendship.

Germany

Now let's look at what Germany will do. She is too rigidly set in her military might and she has too much confidence in her massive regiments for her to abandon her present military organization unless she is compelled to do so, by being drawn into arming by the new armaments of the powers who are her rivals. It is highly unlikely that Germany would ever surprise France by the novel means of an air army. For all these reasons, if we had had a great advance on her—it could have been as much as 10 years—we would have been able to keep it a long time. What a difference from the present situation! Now we can conceive—not without concern—that just the opposite situation could develop.

For the Germans to change their thinking, all it will take is the realization that the Rhine no longer exists as their most powerful defensive barrier. Then, with everything to be redone, they will do it, there and everywhere.

Quietly, systematically, with her Teutonic tenacity, using the intelligence of her people, and also using without scruple all she can learn through espionage, Germany will completely transform her armament. From a land power she will become essentially an airpower. For her neighbors this will be another danger taking shape.

I cannot set down here all my thoughts about the part of this danger that especially threatens France, and which will be her lot if she remains in a culpable attitude of indifference—I fear I would be accused of being a prophet of doom. I will only

point out three basic considerations in air strategy upon which all the others depend.

Berlin is very far from Paris and London; in aerial terms she has over those capitals the immense advantage of relative inaccessibility. To be sure this is a relative advantage, not an absolute one. But how many air battles must be fought, and how many fortified bases must be destroyed before reaching the goal?

The line of the Rhine, with its formidable strong points of Cologne, Coblentz, Mainz, Strasbourg, and others in between which are spread along the stream, will recover the importance lost earlier through the multitude of air bases which will be built there. There is no doubt that they will all be placed along the right bank of the stream, close to one another. The aerial machines they hold will always be ready to take off on devastating raids. As a result along our frontier we will be in a constant state of alert.

Worst of all there is Metz, this terrible fang that has thrust into our territory since the time of the Treaty of Frankfurt. The Germans will work to make it even more menacing and more dangerous by creating huge, fortified bases containing masses of flying machines that can fly toward Paris at a moment's notice and be there within two hours! Metz will be like some massive hammer constantly suspended over our heads, and this is the hammer I was referring to when I talked about the anvil on the other side of the Channel. One might instead consider Metz to be a torch burning constantly!

These are the three basic ideas regarding the east that French air strategists will have the task of examining further.

European Consequences

I have said nothing of Russia, Austria, Italy, Spain, or the minor powers, but the time will come when they will need to be looked at seriously. For the time being all of our reflections, all of our prudence, and all of our defensive efforts should be concentrated on the northern, western, and eastern sections of France.

Without making any claim of foresight, it is possible to foresee that breakdowns in diplomacy could take Europe by sur-

prise, and from one deduction to the next, one can see what might be the result.

An Anglo-German War

England does not like anyone to touch the pound sterling; Germany continues to extend her power onto the seas. These are two considerations that do not make for good relations. Bruised feelings could engender a squabble, or from some incident, some pretext, the growing enmity and the boiling hatred could turn the two into open enemies.

Once a naval war has become inevitable, it will be bitterly fought until the ships of one of the belligerents are annihilated. But if one of the two navies should have a larger number of airplane-carrier ships, the contest would turn in its favor, and its advantage would increase with the number of its naval airplanes, which would soon sink the adversary's fleet or reduce it to impotence. One can foresee an end to the naval war, but not the return of peace.

There would still be the hostilities in the air; these would be no less important for the belligerents and troublesome to our neutrality, producing serious complications. Indeed we will see that this air war could scarcely take place save at our expense and that it would be no small task to keep from becoming its victim.

From what I have written above, the reader should have some idea of just how great would be the air and air-land armament of England and of Germany. Should England wish to take the offensive, how else could she reach Germany than through the airspace over France? If we exclude Belgium, there is no other way. If we tried to stop her, we would be in immediate dispute with her; if we let her cross our territory, with or without the possibility of using our airfields, this would be a provocation as far as Germany was concerned. Should it be the Germans who decided to attack, the result would be the same.

But if France were very strong in the air, as she should be, then if she were firm and fair in her neutrality, she would surely make both belligerents respect her frontiers; she could even interpose herself between them as an umpire. The happy

consequence of this action would be the end of hostilities and the return of peace.

But if, on the other hand, the weakness of France made it impossible for her to bar the passage of air armies, then inevitably they would engage combat over our heads; then, whether we liked it or not, the victor would use our air bases to continue the war and pursue the adversary to his homeland in order to make him capitulate. The result would be one victor but two defeated, one of whom—ourselves—would not have fought.

But after the end of all these air battles fought during the military occupation of French territory by the two opposing nations, we still don't know which of them might be victorious. Suppose to begin with that it were England; let's see what would follow. After having forced the redoubtable position of Metz and gained control of the whole long defensive line of the Rhine by destroying the airfields and all the strongholds that line the stream—and, above all, bringing down all the enemy's planes—the English would have covered themselves with glory in countless air battles, but they still would have taken only the first step. This conquest of Alsace-Lorraine would simply have put them on the road to Berlin.

If ever the English go across Germany, then immediately they would encounter innumerable difficulties. Vertical batteries would be watching for them on their passage or near airfields. Whatever was left of the defeated air army would take to the air as best it could and harass them ceaselessly, withdrawing slowly into the interior. The English would advance slowly and with difficulty, and only on condition that they establish sufficient bases, solidly fortified strong points, and numerous fortified airfields. It is true that once near the Prussian capital, the English would stop within airplane range, and from there they would fly to Berlin to bomb it.

And who knows whether the English, once they had learned the advantages of airplane-carrier ships, would not have constructed large numbers of them—unless they might prefer, once the naval war was successfully concluded, to go through the Baltic to one of the bays in the gulf of Pomerania, and from there launch their bombers against Berlin.

I have tried here to indicate all the multitudes of problems that would attend such a gigantic air campaign, and yet at the same time acknowledge that such a campaign could quite likely be carried out.

Now, let's look at the opposite side of the coin: Germany is victorious. She would be harsh, installing herself among us as if she were at home. If necessary she would build whatever was needed on the Channel coast; then, taking infinite precautions so as not to be taken by surprise, she would treat the Pas de Calais as if it were an extension of Alsace-Lorraine.

Then, have at the English! Happily for them, their formidable aerial Gibraltars would be ready to receive the Prussian aviators. The fight would be a hot one; despite the fall of airplanes of both sides onto the ground or into the water, the pace of the aerial combat would not slacken. The vertical artillery would fire masses of shells whose explosions would darken the sky. The English aviators, astounded by the onslaught, would abandon the defenses around London and hurl themselves into the air in great masses like flocks of crows to confront their enemies.

And when it's over, who will be the victor? I could not hazard a guess. But what is clear is that the victor will make the vanquished pay dearly.

As for we French, whatever happens, we will have been the victims of our own lack of foresight and the excesses of the belligerents. Our fate is clear: it would be our ruin!

Probabilities of Aerial Alliance

Diplomacy either resolves or exacerbates international relations. When it fails, then arms decide the issue. With present armament one can almost count on the possibilities of success or failure. We know in advance that the mobilization of a certain power will take a certain number of days, and that the battles will take place near a certain locality. Between nations the numbers of soldiers and cannons are calculated, and the degrees of superiority or weakness estimated; and it is these presumptions that guide nations in their choice of alliances.

The transformation from land armies to air armies will make a profound change in all the economic, political, diplomatic, and military conditions in Europe, and from these new conditions it will be impossible at first to draw any precise implications. And among so many contradictory influences, the keenest intellect will not suffice to discern the most advantageous alliance from the aerial standpoint.

I have already indicated that the powers that will be most immediately affected by the appearance of military aviation are England, France, and Germany; for the moment I can see no others.

The reflections I have made on the theme England versus Germany prevent me from forming any idea of an alliance between them. Their rivalries and economic ambitions are only beginning and will perpetuate the discord between them. Moreover, to what end would they ally with each other? To join together in crushing France? This is not to be feared, for Germany would soon become preponderant and would not fail to translate into reality the idea of her presence on the Channel coast, and the English would never consent to this. As a consequence at this time nothing indicates the possibility of an Anglo-German alliance.

Now let's examine what the effects would be in the case of a Franco-German alliance. Immediately England would read into it the preparation for an air war against her and would prepare herself accordingly. Let's suppose this war takes place and England is beaten and London lies in ashes. Germany will fall upon us on some pretext, Paris will be spared no more than London, and the Germans will find themselves the complete masters of Europe. Now let's reverse the roles. France is ruined, and Germany as well; England would be rid of her rivals and would become omnipotent. We can see from this brief exposé that we would always be the dupes. So, there would be no Franco-German alliance.

Let's look at the advantages we would receive from an Anglo-French alliance. Germany in turn would become the antagonist. If war came, perhaps without prior declaration, great air armies from Metz would take us by surprise, and we would have to sustain the first blows alone. If the resistance of our

lines of defense in the east were insufficient or badly planned, enemy aviators would come to meet the combined air forces of Vincennes and Satory before the English could reach Paris; and this battle would decide the fate of our capital. The English airplanes would probably arrive too late to help us.

No other explanations are needed; England alone would profit from this alliance because she has an interest in seeing France preserved in order to preserve herself. But if such an agreement seems logical, it would be no less dangerous.

Conclusion

France would draw no advantage from any offensive or defensive alliance with either England or Germany. Neutrality alone can save her, on condition that she leads Europe in military aviation.

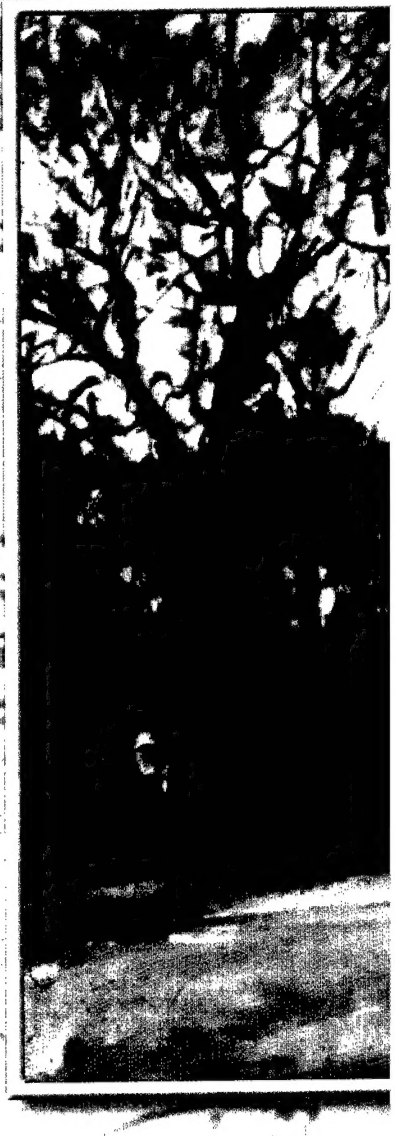
If she remains weak, she will risk disappearing, or suffer the humiliating fate of a vassal nation.

Notes

1. This note, written as an introductory lecture in the strategy course at the School of Military Aviation, was also to be presented at the aeronautical congress cited earlier, but circumstances prevented this.
2. See the brochure *La première étape de l'aviation militaire en France.*
3. At the time Ader was writing, Metz was in German hands, just inside the German frontier. Ader was right to see it as a danger, since the Germans built a dirigible shed there that caused great concern to French military and political leaders (editor's note).
4. This idea was put into practice in a number of European countries prior to 1914, with civilian pilots and their aircraft enrolled in a sort of aerial reserve (editor's note).
5. A type of explosive (editor's note).

This book—the first English translation of Clément Ader's *L'Aviation militaire*—contains Ader's ideas about flight formed in the last decade of the nineteenth century, arranged in manuscript form by Ader in 1907, and published in 1909 in Paris by Berger-Levrault. The text is reproduced in its entirety, including notes added by Ader and explanatory notes and a bibliographical note by the editor and translator, Lee Kennett.

Ader explains his ideas about the development of airplanes based on creatures in nature. He studied the bat and the bird, especially the vulture. Chapters detail the design of bases for aircraft; runway construction; naval airplanes; vertical artillery; air lanes (currents in the air that support aircraft without the need for propulsion); schools of aviation, airplane design, and construction, including curricula; and strategy for waging war in the air. Ader envisioned all of this a decade before the Wright brothers first flew.



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ISBN 1-58566-118-X